American National Standard

for advanced data communication control procedures (ADCCP)

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American National Standard for Advanced Data Communication Control Procedures (ADCCP)

Secretariat

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Abstract

Data communication control procedures define the means for exchanging data between business machines (e.g., computers, concentrators, and terminals) over communication circuits. The advanced data communication control procedures (ADCCP) described in this standard are synchronous, bit oriented (i.e., use bit patterns instead of ASCII characters for control), code independent (i.e., are capable of handling any data code or pattern), and interactive (i.e., have relatively high efficiency in an interactive application). Batch operation is handled with efficiency comparable to that in American National Standard Procedures for the Use of the Communications Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links, ANSI X3.28-1976. Improvements have also been made with respect to ANSI X3.28-1976 in the areas of reliability and modularity.

American National Standard

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Foreword

(This Foreword is not a part of American National Standard for Advanced Data Communication Control Procedures (ADCCP), ANSI X3.66-1979.)

The development of advanced data communication control procedure standards began in late 1969 during final work on American National Standard Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links, ANSI X3.28-1971. At that time, it was recognized that the link control procedures defined in ANSI X3.28 lacked certain desirable capabilities but that it would be impractical to incorporate them in ANSI X3.28 due to the basic philosophy of the standard. Consequently, several proposals were submitted by members of the Task Group for new and improved ways to perform the necessary link control functions. One of the most significant proposals was a bit-oriented approach that utilized dependent single sequence numbering. Out of this activity evolved a proposal for an American National Standard for ADCCP – Dependent Numbering. In late 1971 an approach was proposed based on an independent/dual numbering philosophy. Acceptance of this approach resulted in this American National Standard for ADCCP.

The basic objectives of the Advanced Data Communication Control Procedures are to provide for:

(1) Full transparency and code independence
(2) Efficient interactive and batch operation
(3) A high level of reliability
(4) Two-way alternate and two-way simultaneous operation
(5) A high level of modularity

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, Inc, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Computers and Information Processing, X3. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard for submittal to ANSI, the X3 Committee had the following members:

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Contents

Figures

Appendixes

List of Abbreviations

A - Address field
ABM - Asynchronous balanced mode
ADCCP - Advanced data communication control procedures
ADM - Asynchronous disconnect mode
ARM - Asynchronous response mode
ARO - Asynchronous respond opportunity
BA - Balanced, asynchronous class
C - Control field
C - Combined station (Figure 10-1 only)
CCITT - International Telegraph and Telephone Consultative Committee
Comb - Combined (station)
DISC - Disconnect (command)
DM - Disconnect mode (response)
ECMA - European Computer Manufacturers Association
F - Flag
F bit - Final bit
FCS - Frame check sequence
FRMR - Frame reject (response)
I - Information (command, response)
I - Information format (frame)
I frame - Information format frame
ID - Identification
IM - Initialization mode
IS - Initialization state
ISO - International Standards Organization
ITS - Information transfer state
LDS - Logically disconnected state
LSB - Least significant bit
M - Modifier function bit
MSB - Most significant bit
N - An integer variable
NA - Not applicable
NDM - Normal disconnect mode
N(R) - Receive sequence number
NRM - Normal response mode
NRO - Normal respond opportunity
N(S) - Send sequence number
P bit - Poll bit
P - Primary station (Figure 10-1 only)
P/F bit - Poll or final bit
P/S/C - Primary or secondary or combined (station)
R - Receive variable
RD - Request disconnect (command)
RSET - Reset (command)
REJ - Reject (command, response)
RIM - Request initialization mode (response)
RNR - Receive not ready (command, response)
RR - Receive ready (command, response)
S - Depending upon usage: - Send variable
- Supervisory function bit
- Supervisory format (frame)

S frame - Supervisory format frame
S - Secondary station (Figure 10-1 only)
SABM - Set asynchronous balanced mode (command)
SABME - Set asynchronous balanced mode extended (command)
SARM - Set asynchronous response mode (command)
SARME - Set asynchronous response mode extended (command)
SIM - Set initialization mode (command)
SNRM - Set normal response mode (command)
SNRME - Set normal response mode extended (command)
SREJ - Selective reject (command, response)
TO - Time-out
TWA - Two-way alternate
TWS - Two-way simultaneous
U - Unnumbered format (frame)
U frame - Unnumbered format frame
UA - Unnumbered acknowledgement (response)
UA - Unbalanced, asynchronous class
UI - Unnumbered information (command, response)
UN - Unbalanced, normal class
UP - Unnumbered poll (command)
XID - Exchange identification (command, response)
W,X,Y,Z - Bits in FRMR status field

NOTE: The mathematical symbols and abbreviations used in Section 12, Frame Check Sequence (FCS) Generation and Checking, and Appendix D, Frame Check Sequence (FCS), are not included above; they are defined as introduced in Section 12 and Appendix D.

American National Standard for Advanced Data Communication Control Procedures (ADCCP)

1. SCOPE

This standard establishes the procedures to be used on synchronous communication links using ADCCP. This standard does not define any single system and should not be regarded as a specification for a data communications system.

This standard is intended to cover a wide range of applications (e.g., two-way alternate and two-way simultaneous data communication between computers, concentrators, and terminals which are normally buffered) and a wide range of data link configurations (e.g., full and half-duplex, multipoint, point-to-point, switched or nonswitched).

This standard is defined specifically in terms of the actions that occur on receipt of commands at secondary stations and combined stations.

In order to provide a high degree of standardization (and, therefore, of compatibility), any equipment intended to be operated within the constraints of this standard shall implement all features of a stipulated basic class of the procedures.

CAUTION NOTICE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

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2. GENERAL

ADCCP defines a method of data link control in terms of the various combinations of primary link control functions (referred to as a primary station), secondary link control functions (referred to as a secondary station), and balanced link control functions (referred to as a combined station) that make up the control functions and protocols at three types of logical data link control stations:

(1) Primary station
(2) Secondary station
(3) Combined station

In particular, the logical functions and protocols of secondary stations and combined stations are specified identically with respect to the action taken and the response frame(s) transmitted as the result of receiving a given command frame(s). The primary station and combined station procedures for managing and scheduling the data link, via the transmission of command frames, are the responsibility of the system designer and are not specified in this standard.

Since this standard is defined in terms of logical stations it should be noted that a given physical station may be composed of one or more logical stations. For example, a physical station implementation may: (1) have the capability of providing more than one type of logical station capability on a given link at different times (see 2.1.4); (2) have the capability of providing more than one logical station capability on different links at the same time (e.g., a multiplexor that serves several links); (3) house or serve multiple logical stations (e.g., a cluster controller).

2.1 Station Types

In ADCCP there are three types of stations: primary station; secondary station; combined station.

NOTE: As used in this document the word station (by itself) refers to all three types of stations: primary, secondary, and combined.

2.1.1 Primary Station

A primary station has only a primary link control capability. The primary station transmits command frames (commands) to and receives response frames (responses) from the secondary station(s) on the link. A primary station maintains a separate information transmitting ability or information receiving ability, or both, with each secondary station on the link.

2.1.2 Secondary Station

A secondary station has only a secondary link control capability. The secondary station transmits response frames (responses) to and receives command frames (commands) from the primary station. It maintains one information transmitting ability or one information receiving ability, or both, with the primary station.

2.1.3 Combined Station

A combined station has balanced link control capability. The combined station transmits both command frames (commands) and response frames (responses) to, and receives both commands and responses from, another combined station. It maintains one information transmitting ability to and one information receiving

ability from the other combined station.

2.1.4 Stations Capable of Being Configured

A station is defined as configurable if it has, as the result of mode-setting action, the capability to be, at different times, more than one type of logical station; i.e., primary station, secondary station, or combined station.

2.2 Logical Data Link Configurations

In ADCCP there are two logical data link configurations:

(1) Unbalanced configurations which have a primary station and one or more secondary stations.

(2) Balanced configurations which have two combined stations.

2.2.1 Unbalanced Configurations

An unbalanced configuration has one primary station and one or more secondary stations connected to the link. The link may be point-to-point or multipoint, two-way alternate or two-way simultaneous, switched or nonswitched. In the unbalanced configuration the primary station is responsible for setting each secondary station in a logical state and mode as appropriate. See Section 6. Additionally, both primary and secondary stations are responsible for exchanging data and control information with each other, and initiating the link level error recovery functions defined in this standard. See Figure 2-1.

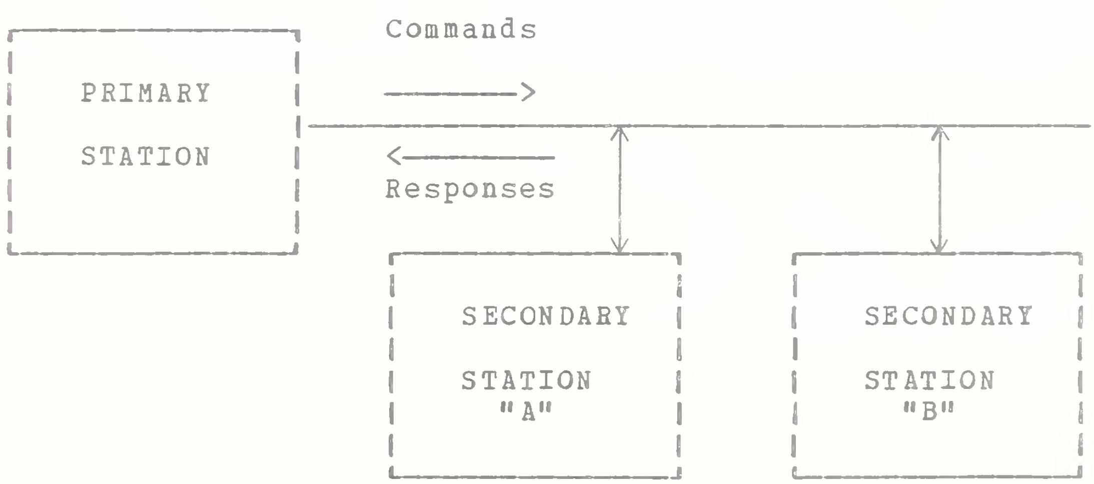


Figure 2-1 Unbalanced Configuration

2.2.2 Balanced Configurations

A balanced configuration consists of two combined stations connected point-to-point, two-way alternate or two-way simultaneous, switched or nonswitched. Both combined stations have compatible data transfer and link control capability. See Figure 2-2.

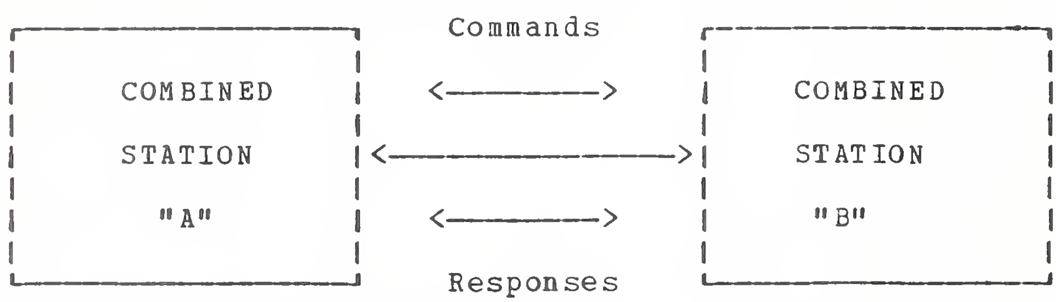


Figure 2-2 Balanced Configuration

2.2.3 Symmetric Configurations

Two independent point-to-point unbalanced logical station configurations may be connected in a symmetric manner and multiplexed on a single link. This configuration may be two-way alternate or two-way simultaneous, switched or nonswitched. In this configuration there are two independent primary-station-to-secondary-station logical channels where the primary stations have overall responsibility for mode setting. Each of the four stations maintains one information transmitting ability or one information receiving ability, or both. See Figure 2-3.

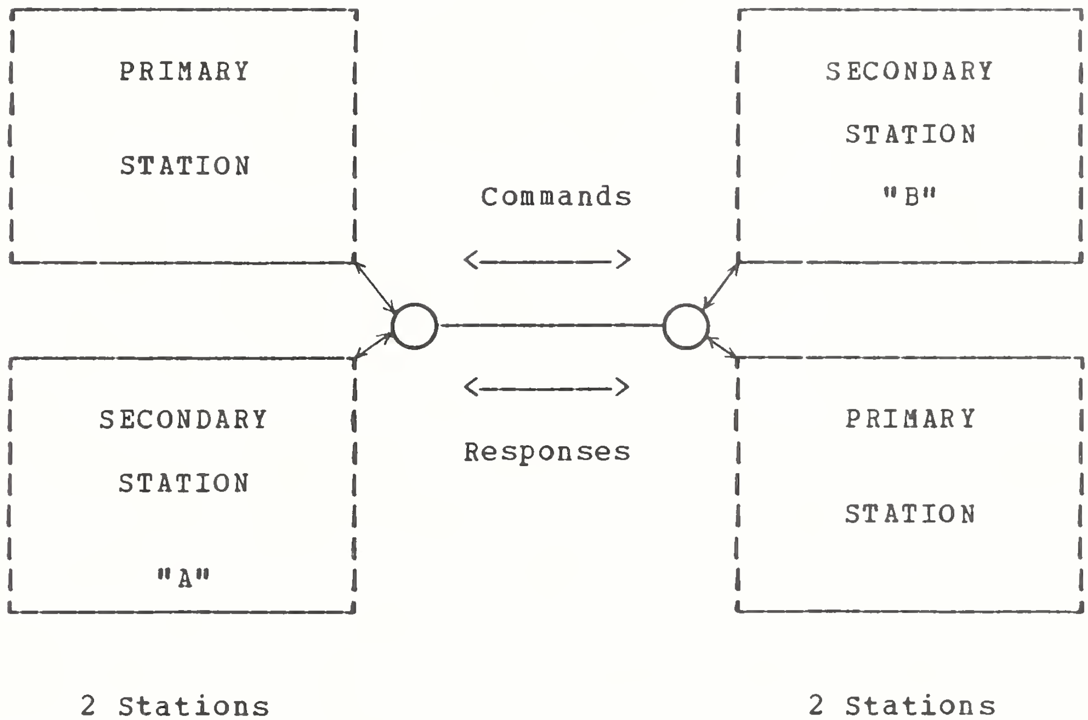


Figure 2-3 Symmetric Configuration

2.3 Logical States and Modes

Communication between two stations is conducted in three logical states: information transfer state, initialization state, or logically disconnected state.

2.3.1 Information Transfer State (ITS)

While in the ITS, the secondary/combined station may transmit and receive information. Communications shall observe the constraints of a mode established in a secondary/combined station by the remote primary/combined station. Each mode specifies a respond opportunity and a logical data link configuration. See 6.2.

2.3.1.1 Normal Response Mode (NRM)

NRM is an unbalanced configuration operational mode in which the secondary station may initiate transmission of frames containing information only as the result of receiving explicit permission to do so from the primary station. After receiving permission, the secondary station shall initiate a response transmission. The response transmission may consist of one or more frames while

maintaining an active channel state. The last frame of the response transmission will be explicitly indicated by the secondary station. Following the indication of the last frame, the secondary station will stop transmitting until explicit permission is again received from the primary station.

2.3.1.2 Asynchronous Response Mode (ARM)

ARM is an unbalanced configuration operational mode in which the secondary station may initiate transmission without receiving explicit permission from the primary station. Such an asynchronous transmission may contain single or multiple frames and is used for information field transfer or to indicate status changes in the secondary station (e.g., the number of the next expected frame, transition from a ready to a busy condition or vice versa, occurrence of an exception condition), or both.

2.3.1.3 Asynchronous Balanced Mode (ABM)

ABM is a balanced configuration operational mode in which a combined station may initiate transmission without receiving permission from the other combined station. Such an asynchronous transmission may contain single or multiple frames for information transfer or to indicate status changes at the transmitting combined station (e.g., the number of the next expected frame, transition from a ready to a busy condition or vice versa, occurrence of an exception condition), or both.

2.3.2 Initialization State (IS)

While in the IS, communications shall observe the constraints of a system-defined procedure. The system-defined procedure may, for example, cause the secondary/combined station's link control to be initialized or regenerated by the remote primary/combined station. See 6.4.

2.3.3 Logically Disconnected State (LDS)

While in the LDS, the secondary/combined station is logically disconnected from the link and is not permitted to transmit or receive information. Communications shall observe the constraints of a disconnected mode selected by system definition; each mode specifies a respond opportunity. See 6.3.

2.3.3.1 Normal Disconnected Mode (NDM)

NDM is an unbalanced configuration nonoperational mode in which the secondary station is logically disconnected from the link and is not permitted to initiate or receive information. The secondary station may initiate transmission only as the result of receiving explicit permission to do so from the primary station. After receiving permission, the secondary station shall initiate a single frame transmission indicating its status.

2.3.3.2 Asynchronous Disconnected Mode (ADM)

ADM is an unbalanced or balanced configuration nonoperational mode in which the secondary/combined station is logically disconnected from the link and is not permitted to initiate or receive information. A station in ADM may initiate transmission without receiving explicit permission from the primary/combined station but the transmission shall be a single frame indicating the station status.

3. FRAME STRUCTURE

In ADCCP, all transmissions are in frames and each frame conforms to the following structure:

F, A, C, Info, FCS, F
Where:
F = Flag sequence
A = Address field
C = Control field
Info = Information field
FCS = Frame check sequence

Frames containing only data link control sequences form a special case where there is no information field. The short frame structure is therefore:

F, A, C, FCS, F

The elements of the frame are described in the following paragraphs. See also Figure 3-1.

3.1 Flag Sequence (F)

All frames start and end with the flag sequence. This sequence is a zero bit followed by 6 one bits followed by a zero bit (01111110). All stations attached to the data link continuously hunt, on a bit-by-bit basis, for this sequence. A transmitter must send only complete eight-bit flag sequences; however, the sequence of 011111101111110 at the receiver is understood as two flag sequences. The flag is used for frame synchronization.

In order to achieve transparency the flag sequence is prohibited from occurring in the address, control, information, and FCS fields via a "zero bit insertion" procedure described in 3.7.

The flag sequence which closes a frame may also be the opening flag sequence for the next frame. Any number of complete flags may be used between frames. See also Appendix B.

3.2 Address Field (A)

The address field contains the link level address of a secondary station or a combined station. The length of this field (A) is N octets (N is greater than or equal to 1). The encoding of this field is described in Section 4.

3.3 Control Field (C)

The control field contains a command or response and may contain sequence numbers. The control field is used by the transmitting primary/combined station to instruct the addressed secondary/combined station to perform a specific operation. It is also used by the secondary station or combined station to respond to the remote primary station or combined station. The length of this field (C) is one octet in the case of the basic control field. It is two octets in length in the case of the extended control field. See 5.2.2.

Sequence numbers and the formatting of the control field are described in Section 5. Commands and responses are functionally described in Section 7.

3.4 Information Field

The information field may be of any number and sequence of bits; the data link procedures are completely transparent. Data contained in the information field is unrestricted with respect to code or grouping of bits. See Appendix B for examples of typical limitations on maximum length.

3.5 Frame Check Sequence (FCS)

All frames include a 16-bit frame check sequence (FCS) just prior to the closing flag for error detection purposes. The contents of the address, control, and information fields, excluding the zeros inserted to maintain transparency per 3.7, are included in the calculation of the FCS sequence.

The FCS is the remainder of a modulo 2 division process utilizing a generator polynomial as a divisor. The generator polynomial is that used in International Telegraph and Telephone Consultative Committee (CCITT) Recommendation V.41, Code-Independent Error Control System, and is: $X^{16} + X^{12} + X^5 + 1$. Recommendation V.41 is part of CCITT Sixth Plenary Assembly, Vol VIII.1, Data Transmission Over the Telephone Network, and can be obtained from the International Telecommunication Union, Geneva, Switzerland.

Section 12 gives a complete description of the FCS generation process and the error checking process which utilizes the FCS. Appendix D gives an example of FCS generation and error detection.

NOTE: If future applications show that a higher degree of protection is needed, the length of the FCS will be increased by multiples of eight bits. This procedure requires a higher degree generator polynomial, the implementation and use of which is outside the scope of this standard.

3.6 Abort

In the abort procedure a station in the process of sending a frame ends the frame in an unusual manner such that the receiving station will ignore the frame.

Aborting a frame is performed by transmitting at least seven, but less than fifteen, contigucus one bits (with no inserted zeros). Receipt of seven contiguous one bits is interpreted as an abort. Receipt of fifteen or more contiguous one bits is interpreted as an abort and idle link state. See 3.9.

3.7 Transparency

ADCCP provides transparency for data coded in the information field. The occurrence of the flag sequence within a frame is prevented via a "zero bit insertion" procedure as follows:

The transmitter inserts a zero bit following five contiguous one bits anywhere between the opening flag and the closing flag of the frame. The insertion of the zero bit thus applies to the contents of the address, control, information and FCS fields (including the last 5 bits of the FCS). The receiver continously monitors the received bit stream; upon receiving a zero bit followed by five contiguous one bits, the receiver inspects the following bit. If it is a zero, the 5 one bits are passed as data and the zero bit is deleted; if the sixth bit is a one, the receiver inspects the seventh bit; if it is zero, a flag sequence has been received; if it is a one, an abort has been received. See 3.6.

3.8 Active Link State and Interframe Time Fill

A link is in an active state when a primary station, secondary station, or combined station is actively transmitting a frame, an abort sequence, or interframe time fill. When the link is in the active state, the right of the transmitting station to continue transmission is reserved.

Interframe time fill is accomplished by transmitting continuous flags between frames. There is no provision in this standard for the specification of intraframe time fill. See also Appendix B.

3.9 Idle Link State

A link is in an idle state when a continuous ones state is detected that persists for at least 15 bit times.

Idle link time fill is a continuous one condition on the link.

3.10 Invalid Frame

An invalid frame is one that is not properly bounded by two flags (thus an aborted frame is an invalid frame) or one which is too short (i.e., shorter than 32 bits between flags). A secondary station or combined station will ignore any invalid frame.

3.11 Order of Bit Transmission

Addresses, commands and responses, and sequence numbers shall be transmitted low-order bit first (e.g., the first bit of a sequence number that is transmitted carries the weight 2^0). See Figure 3-1.

The order of bit transmission for data contained within the information field is application-dependent and is not specified in this standard.

The order of bit transmission for the FCS is most significant bit first. See Appendix D.

```
|                                                                      |
|                                FRAME                                 |
|<-------------------------------------------------------------------->|
|                                                                      |
|                                                                      |
|+---First Bit                                                         |
||    Transmitted                                                      |
||                                                                     |
|v                                                                     |
|   F          A          C          (Info)          FCS            F  |
|----------------------------------------------------------------------|
|01111110 |  Note 1  |  Note 2  |  Note 3  |  X15---------X0 | 01111110|
|         |          |          |          |                 |         |
+----------------------------------------------------------------------+

 Flag       Address    Control    Information  Frame Check     Flag
 Sequence   Field      Field      Field        Sequence        Sequence
```

Note 1. Address field formats described in 4.3.1 and 4.3.2.

Note 2. Control field formats described in 5.2.

Note 3. Information field size may be any number of bits.

Figure 3-1

Structural Relationship of Defined Fields in ADCCP Format

4. ADDRESS FIELD

4.1 Unbalanced Operation

A unique address is associated with every secondary station on a link. Additionally, a secondary station may be capable of accepting frames which utilize a group or global address; however, when such a secondary station responds, it will utilize its unique address.

The address field in a command frame transmitted by a primary station contains the address of the (remote) secondary station. The address field in a response frame transmitted by a secondary station contains the address of the (local) secondary station.

4.2 Balanced Operation

A unique address is associated with each combined station on the link. Additionally, a combined station may be capable of accepting frames which utilize a group or global address; however, when such a combined station responds it will utilize its unique address.

The address field in a command frame transmitted by a combined station contains the address of the remote combined station. The address field in a response frame transmitted by a combined station contains the address of the local combined station.

4.3 Address Encoding

Two address encoding formats are defined for the address field: basic and extended. These formats are mutually exclusive for any given secondary station or combined station on a link and, therefore, the addressing format must be explicitly specified.

4.3.1 Basic Address Format

In basic address format, the address field contains one address, which may be a single secondary/combined station address, or a group or global secondary/combined station address. This field consists of one octet with the following format:

Address field bit number	1	2	3	4	5	6	7	8
Address								

Least significant bit
First bit transmitted

4.3.2 Extended Address Format

In extended format, the address field is a sequence of octets which comprises one address which may be a single secondary/combined station address, or a group or global secondary/combined station address. When the first bit of an address octet is "0", the subsequent octet is an extension of the address field. See 4.5 for exception. The address field is terminated by an octet having a "1" in bit position one. Thus, the address field is recursively extendable. The format of the extended address field is as follows:

```
Extension Indicators----------------------------------------------------------------
                          |                          |                          |
                          |                          |                          |
                          v                          v                          v

Address Field             1  2  3  4  5  6  7  8    9                                  8n
Bit Number               |0 |  |  |  |  |  |  |  | |0 |  |  |  |  |  |  |  |  |1 |  |  |  |  |  |  |  |
                          <-------------------->                        <-------------------->
                           ^         ^                                        ^          ^
                           |         |                                        |          |
First Bit Transmitted------|         |                                        |          |
                           |         |                                        |          |
Least Significant Bit------          |                                        |          |
                                     |                                        |          |
First Octet of Address Field    -----                                         |          |
                                                                              |          |
Last Octet of Address Field      ---------------------------------------------           |
                                                                                         |
Most Significant Bit      ---------------------------------------------------------------
```

4.4 Global Address

The single octet address of eight "1" bits (11111111) is reserved as the global (universal, or broadcast) address in the basic and extended address formats.

The global address is used in situations where a specific secondary/combined station address is not known (e.g., switched connection) or is not relevant to the situation (e.g., broadcast transmission).

4.5 Null Address

When the first octet of the address field appears as eight "0" bits (00000000), the address is considered to be a null (no station) address and the frame will be ignored.

5. TRANSMISSION PARAMETERS AND FORMATS

For definitions of the following commonly used terms see Glossary, Appendix A.

- Accept/Acceptance
- Acknowledge
- Action
- Discard
- Implement
- Invalid
- Receive
- Respond opportunity

5.1 Parameters

The various parameters associated with frames are described in 5.1.1 through 5.1.3. Figure 5-1 shows the position of parameters within a frame.

5.1.1 Modulus

Each information (I) frame is sequentially numbered and may have the value 0 through modulus - 1 (where modulus is the modulus of the sequence numbers). Modulus equals 8 for the basic control field format and 128 for the extended control field format. The sequence numbers cycle through the entire range.

The maximum number of sequentially numbered I frames that a station may have outstanding (i.e., unacknowledged) at any given time may never exceed one less than the modulus of the sequence numbers. This restriction is intended to prevent any ambiguity in the association of transmitted I frames with sequence numbers during normal operation or error recovery action, or both. The number of outstanding I frames may be further restricted by either the sending or receiving station storage capability; e.g., the number of I frames that can be stored for transmission or retransmission (in the event of a transmission error), or both.

5.1.2 Frame Variables and Sequence Numbers

Every secondary station in an information transfer state maintains a send variable on the I frames it transmits to, and a receive variable on the I frames it correctly receives from, the primary station. Every primary station maintains an individual send variable on the I frames it transmits to, and an individual receive variable on the I frames it correctly receives from, each secondary station in an information transfer state. Every combined station in an information transfer state maintains one send variable on the I frames it transmits to, and one receive variable on the I frames it correctly receives from, the remote combined station.

5.1.2.1 Send Variable (S)

Each station capable of transmitting I frames has a send variable S which indicates the sequence number of the next I frame to be transmitted. S shall take on the value 0 through modulus - 1. S is incremented by one with each completed I frame transmission (i.e., S will not be incremented when an I frame transmission is aborted).

5.1.2.2 Send Sequence Number (N(S))

Only I frames contain N(S), the sequence number of the transmitted frame. Prior to transmission of an I frame, N(S) is set equal to S.

5.1.2.3 Receive Variable (R)

Each station capable of receiving I frames shall have a receive variable R equal to the expected N(S) contained in the next I frame received. R is incremented by one upon receipt of an error-free I frame whose N(S)=R.

5.1.2.4 Receive Sequence Number (N(R))

All I frames and supervisory (S) frames contain an N(R), the expected sequence number of the next received I frame. Immediately before transmitting or retransmitting an I or S frame, N(R) is set equal to R. N(R) thus indicates that the station transmitting the N(R) has correctly received all I frames numbered up to and including N(R)-1.

5.1.3 Poll/Final (P/F) Bit

Poll (P) and final (F) bits are used for:

(1) Indicating when a secondary station may begin and has finished a response transmission under NRM. See 6.2.1.

(2) Checkpointing to determine if error recovery is required. See 6.5.2.

(3) Obtaining a response from a secondary/combined station. See 6.1.

The P bit set to "1" is used by the primary/combined station in command frames to solicit (poll) a response or sequence of response frames from a secondary station(s) or a combined station.

The F bit set to "1" is used by a secondary station to:

(1) Indicate in ARM the response frame sent in reply to the receipt of a poll command.

(2) Indicate in NRM the final frame transmitted as the result of a previous poll command.

The F bit set to "1" is used by a combined station to indicate in ABM the response frame sent in reply to the receipt of a poll command.

See 6.1 for further description of the P/F bit operation.

5.2 Control Field Formats

The three formats defined for the control field are used to perform information transfer, basic supervisory control functions, and special cr infrequent control functions.

5.2.1 Basic Control Field

The basic control field accommodates modulo 8 N(S) and N(R) sequence numbering.

```
                                         <-------Control Field--------->
   First Bit Transmitted       ------------┐
                                           ↓
   Control Field Bits                      1   2   3   4   5   6   7   8
                                           -   -   -   -   -   -   -   -
                                        ┌─────────────────────────────────┐
   Information Transfer Format          |0 | N(S)        | P/F |   N(R)   |
                                        |  |             |     |          |
                                        |────────────────┼─────┼──────────|
   Supervisory Format                   |1   0 | S     S | P/F |   N(R)   |
                                        |      |         |     |          |
                                        |──────┼─────────┼─────┼──────────|
   Unnumbered Format                    |1   1 | M     M | P/F |M   M   M |
                                        |      |         |     |          |
                                        └─────────────────────────────────┘
```

Where: N(S) = Transmitting station send sequence number.
(Bit 2 = low order bit)
N(R) = Transmitting station receive sequence number.
(Bit 6 = low order bit)
S = Supervisory function bits
M = Modifier function bits
P/F = Poll bit - primary/combined station command frame transmissions.
Final bit - secondary/combined station response frame transmissions.
(1 = Poll/Final)

5.2.2 Extended Control Field

The extended control field accommodates modulo 128 N(S) and N(R) sequence numbering. On long propogation delay links (e.g., satellite transmission) it is desirable for reasons of efficiency to extend the modulus of the sequence numbers N(S) and N(R).

Control field extension for the three formats is as follows:

```
                                |                                                          |
                                |<---------------- Control Field ------------------------->|
                                |                                                          |
                                |<----1st Octet--------->|<--------2nd Octet----------->   |
                                |                        |                                 |
First Bit Transmitted-----------┐                        |                                 |
                                ||                       |                                 |
                                |v                       |                                 |
 Control Field Bits             |1  2  3  4    5  6  7  8 |  9   10   11   12   13   14   15   16 |
                                |------------------------┐| ┌-----------------------------------┐|
 Information Format             |0|        N(S)          |  |P/F|         N(R)                  |
                                |------------------------|  |---+-------------------------------|
 Supervisory Format             |1  0 |S  S  | X  X  X  X|  |P/F|         N(R)                  |
                                |-----+------+-----------|  |---+-------------------------------|
 Unnumbered Format              |1  1 |M  M  |P/F|M  M  M|  |P/F| X    X    X    X    X    X   X|
                                └------------------------┘  └-----------------------------------┘
```

where X bits are reserved and set to "0".

In extended control field format the transmitter sets the P/F bits in bit positions 5 and 9 for unnumbered format commands and responses. A receiver in extended control field format interprets the P/F bit in bit position 9. A receiver in basic control field format receiving an extended control field format interprets the P/F bit in bit position 5.

5.3 Information Transfer Format (I)

The I format is used to perform an information transfer.

The functions of N(S), N(R), and P/F are independent; i.e., each I frame has an N(S) sequence number, the N(R) sequence number may or may not acknowledge additional I frames at the receiving station, and the P/F bit may or may not be set to "1".

5.4 Supervisory Format (S)

The S format is used to perform link supervisory control functions such as acknowledge I frames, request retransmission of I frames, and indicate temporary interruption of capability to receive I/UI frames. The functions of N(R) and P/F are independent.

5.5 Unnumbered Format (U)

The U format is used to provide additional link control functions. This format contains no sequence numbers and consequently five "modifier" bit positions are available which allow definition of up to 32 additional command and 32 additional response functions.

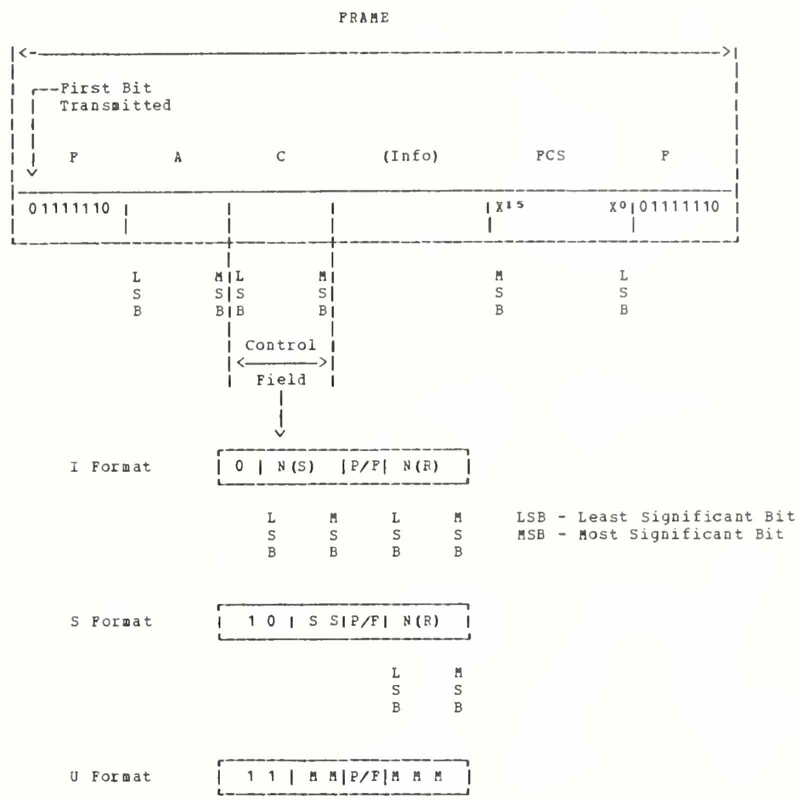


Figure 5-1

Positional Significance of Bits in Fields of ADCCP Basic Format

6. SECONDARY/COMBINED STATION STATES AND MODES

A secondary/combined station transmits response frames to a primary/combined station based on previous receipt of a command frame. In certain cases, a secondary/combined station can also initiate transmission of response frames to a primary/combined station. The characteristics of a secondary/combined station response are determined by: (1) the type of respond opportunity which exists at the secondary/combined station, (2) the current state of the secondary/combined station, and (3) the particular mode within the state of the secondary/combined station. Secondary/combined stations do not queue sequential responses for

command frames received. A secondary/combined station response is predicated on: (1) station status at the time the response is transmitted, (2) an exception condition previously established, or (3) the previous receipt of a command which requires a specific response format.

6.1 Poll/Final Bit Usages

The Poll/Final (P/F) bit serves a function in both command frames and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

The P bit is used to solicit a response frame with the F bit set to "1" from the secondary/combined station at the earliest opportunity. A response frame with the F bit set to "1" also indicates the end of transmission under normal respond opportunity.

For each primary-secondary pair on unbalanced links and for each direction on balanced links only one frame with a P bit set to "1" may be outstanding at a given time. Before a primary/combined station can issue another frame with the P bit set to "1" it must receive a response frame from the secondary/combined station with the F bit set to "1". If no valid response frame is obtained within a system-defined time-out, the retransmission of a command with the P bit set to "1" for error recovery purposes is permitted.

6.2 Respond Opportunities

6.2.1 Normal Respond Opportunity (NRO)

NRO is a secondary station respond opportunity in which the secondary station initiates transmission of response frames only as the result of receiving a command frame with the P bit set to "1" or a UP command. See 7.4.2.2.

The response transmission may consist of one or more frames while the secondary station is maintaining an active link state. In all cases the last frame of the response transmission will have the F bit set to "1". When the response frame with the F bit set to "1" is transmitted, the secondary station will stop transmitting response frames and will not initiate any additional transmission of response frames until a subsequent command frame with the P bit set to "1" is received or until a UP command is received.

6.2.2 Asynchronous Respond Opportunity (ARO)

ARO is a secondary/combined station respond opportunity in which the secondary/combined station initiates transmission of response frames without regard to the receipt of a command frame with the

P bit set to "1". Asynchronous transmission of response frames may be initiated at the first opportunity. In two-way simultaneous (TWS) transmission the opportunity is always present. In two-way alternate (TWA) transmission the opportunity becomes available upon the detection of an idle link state. An asynchronous transmission may contain multiple frames and is used to initiate information transfer (I/UI) or to report status changes in the secondary/combined station (e.g., N(R) number change, transition from a ready to a busy condition or vice versa, or establishment of an exception condition), or both.

The secondary/combined station shall transmit a frame with the F bit set to "1" only in response to a received command frame with the P bit set to "1". The F bit is not to be interpreted as the end of transmission by the secondary/combined station. Additional response frames with the F bit set to "0" may be transmitted following the response frame which had the F bit set to "1".

In TWS operation a secondary/combined station that is in the process of transmitting when the command frame with the P bit set to "1" is received will set the F bit to "1" in the earliest possible response frame to be transmitted.

When a station has asynchronous respond opportunity, it shall utilize a response time-out function which will cause initiation of appropriate recovery procedures if previously transmitted unsolicited response frames have not been acknowledged within a system-defined time-out period. Since simultaneous contention may occur, in TWA configurations the response timers at each end of the link shall be unequal. In TWA, the interval employed by a secondary station shall be greater than that employed by the primary station to permit contention situations to be resolved in favor of the primary station.

6.3 Logically Disconnected State (LDS)

The LDS is provided to prevent a secondary/combined station from appearing on the link in a fully operational sense during unusual situations or exception conditions since such operations could cause (1) unintended contention, (2) sequence number mismatch, or (3) ambiguity as to the secondary/combined station status or mode.

While in the LDS, the secondary station, or the response capability of a combined station, is logically disconnected from the data link; i.e., no information (I), unnumbered information (UI), or S response frames are transmitted or accepted. The secondary station capability, or the response capability of a combined station, is limited to (1) accepting one of the mode-setting commands, (2) transmitting a DM or RIM response frame at each respond opportunity, and (3) responding to an XID command.

A secondary/combined station in the LDS, as a minimum capability, must respond with DM (disconnected mode) to any valid command frame received with the P bit set to "1". A RIM (request initialization mode) response may be transmitted instead of DM; the conditions which cause a secondary/combined station to transmit RIM are system defined.

A mode-setting, XID, or UP command may be accepted and responded to at the first respond opportunity if the station is capable of accepting and actioning the command. Any other frame received, including a mode-setting, XID, or UP command that is not accepted, is discarded except for the response requirement described in the previous paragraph.

A secondary/combined station is system defined with regard to the condition(s) that cause it to assume one of the two predetermined modes (ADM or NDM).

Examples of possible system-defined conditions (in addition to that of receiving a DISC command) which may cause a secondary/combined station to enter the LDS are:

(1) The secondary/combined station power is turned on

(2) The secondary/combined station has a temporary loss of power

(3) The secondary/combined station link level logic is manually reset

(4) The secondary/combined station is manually switched from a local (home) condition to a connected-to-the-link condition.

While in the LDS, a secondary/combined station may not establish a frame reject exception condition.

6.3.1 Modes Within LDS

While in the LDS, a secondary/combined station communicates under the constraints of one of the following two modes.

6.3.1.1 Normal Disconnected Mode (NDM)

NDM is a disconnected mode in which the secondary station is logically disconnected from the data link and follows normal respond opportunity protocol. See 6.2.1.

6.3.1.2 Asynchronous Disconnected Mode (ADM)

ADM is a disconnected mode in which the secondary station, or response capability of a combined station, is logically

disconnected from the data link and follows asynchronous respond opportunity protocol. See 6.2.2.

6.4 Initialization State (IS)

While in the IS, the secondary/combined station may be initialized or regenerated by the remote primary/combined station and communicates under the constraints of the mode specified in 6.4.1.

6.4.1 Initialization Mode (IM)

A secondary/combined station enters the IM upon sending a UA response, under a system-defined respond opportunity, in reply to the receipt of a set initialization mode (SIM) mode-setting command. While in the IM, the stations may exchange information in any manner specified for that secondary/combined station (e.g., unformatted and unchecked bit streams, UI frames, or I frames); however, in a multipoint configuration care shall be taken to prevent interference with other stations on the link. IM is ended when the secondary/combined station receives, actions, and acknowledges a different mode-setting command (i.e., SNRM, SARM, SABM, SNRME, SARME, SABME, or DISC).

The secondary/combined station may request SIM at any time by sending a request initialization mode (RIM) response.

6.5 Information Transfer State (ITS)

While in the ITS, a station is fully operational and capable of transmitting and receiving I, S, and U format frames.

6.5.1 Modes Within ITS

While in the ITS, a secondary/combined station communicates under the constraints of one of the modes specified in 6.5.1.1 through 6.5.1.3. The particular mode utilized is determined by the primary/combined station with an appropriate mode-setting command and is entered when the secondary/combined station receives, actions, and acknowledges that mode-setting command.

6.5.1.1 Normal Response Mode (NRM)

NRM is a secondary station information transfer mode in which the secondary station utilizes normal respond opportunity on an unbalanced link configuration. See 2.2.1 and 6.2.1. This mode is selected by a SNRM or SNRME command.

6.5.1.2 Asynchronous Response Mode (ARM)

ARM is a secondary station information transfer mode in which the secondary station utilizes asynchronous respond opportunity on an unbalanced link configuration. See 2.2.1 and 6.2.2. This mode

is selected by a SARM or SARME command.

6.5.1.3 Asynchronous Balanced Mode (ABM)

ABM is a combined station information transfer mode in which the combined stations utilize asynchronous respond opportunity on a balanced link configuration. See 2.2.2 and 6.2.2. This mode is selected by a SABM or SABME command. A combined station may transmit command frames at any time; therefore, the ABM definition only describes and applies to the response frame transmitting and command frame receiving capability of the combined stations.

6.5.2 Checkpointing

As the P and F bits are always exchanged as a pair (for every P there is one F, and the next P must not be issued until the previous P has been matched with an F or until the response timer expires), the N(R) contained in a frame with a P or F bit set to "1" can be used to detect I frame sequence errors. This capability can provide early detection of frame sequence errors and can indicate the I frame sequence number with which to begin retransmission. This capability is referred to as checkpointing.

While in the ITS, the primary/combined station shall examine the N(R) contained in any received I or S frame with the F bit set to "1". Appropriate error recovery procedures shall be initiated if this N(R) does not acknowledge all I frames transmitted by the primary/combined station prior to and including the last command frame sent with the P bit set to "1". See 8.2.1 for additional qualifying conditions.

Similarly, while in the ITS, the secondary station shall examine the N(R) contained in any received I or S frame with the P bit set to "1". Appropriate error recovery procedure shall be initiated if this N(R) does not acknowledge all I frames transmitted by the secondary station prior to and including the last response frame with the F bit set to "1". See 8.2.1 for additional qualifying conditions.

In all cases the N(R) of a correctly received I or S frame shall confirm previously transmitted I frames through N(R)-1.

7. COMMANDS AND RESPONSES

This standard defines the link control operation in terms of the actions and internal modes of the secondary/combined station. The actual link management procedure (i.e., sequence of commands and related responses) is application and link configuration dependent. Consequently, specific primary/combined station command sequences are not defined by this standard but are left to the designer of the primary/combined station link control.

Subsections 7.1 through 7.3 contain the definition of the set of commands and responses (listed below) for each of the transmission formats.

INFORMATION TRANSFER FORMAT COMMANDS

I - Information

SUPERVISORY FORMAT COMMANDS

RR - Receive ready
RNR - Receive not ready
REJ - Reject
SREJ - Selective reject

UNNUMBERED FORMAT COMMANDS

Mode-Setting Commands

SNRM - Set normal response mode
SARM - Set asynchronous response mode
SABM - Set asynchronous balanced mode
SNRME - Set normal response mode extended
SARME - Set asynchronous response mode extended
SABME - Set asynchronous balanced mode extended
SIM - Set initialization mode
DISC - Disconnect

Information Transfer Commands

UI - Unnumbered information
UP - Unnumbered poll

Recovery Commands

RSET - Reset

Miscellaneous Commands

XID - Exchange identification

Nonreserved Commands

4 Encodings

INFORMATION TRANSFER FORMAT RESPONSES

I - Information

SUPERVISORY FORMAT RESPONSES

RR - Receive ready
RNR - Receive not ready
REJ - Reject
SREJ - Selective reject

UNNUMBERED FORMAT RESPONSES

Mode-Setting Responses

UA - Unnumbered acknowledgement
DM - Disconnected mode
RIM - Request initialization mode

Information Transfer Responses

UI - Unnumbered information

Recovery Responses

FRMR - Frame reject

Miscellaneous Responses

XID - Exchange identification
RD - Request disconnect

Nonreserved Responses

4 Encodings

7.1 Information Transfer Format (I) Command/Response

The function of the information (I) command/response is to efficiently transfer sequentially numbered frames containing an optional information field.

The encoding of the I command/response control field is as follows:

```
                        I Format Command/Response
                  <----------Control Field---------->


   First Bit Transmitted
                       |
                       |
                       v

 Control Field Bits:   1   2   3   4   5   6   7   8
                     ┌─────────────────────────────────┐
                     | 0 |    N(S)     |P/F |  N(R)     |
                     └─────────────────────────────────┘
                       |       |       |       |
                       |       |       |       |
                       |       |       |       v
                       |       |       |
                       v       |       |     Receive Sequence
                               |       |     Number Modulo 8
              Information      |       v
            Transfer Format    |
                               |     Command: Poll
                               |     Response: Final
                               v

                         Send Sequence
                        Number Modulo 8
```

For extended control field format see 5.2.2.

The I frame control field contains two sequence numbers: N(S), send sequence number, which indicates the sequence number associated with the I frame; N(R), receive sequence number, which indicates the sequence number of the next expected I frame (i.e., I frames numbered up to and including N(R) - 1 are accepted).

An I frame with P/F bit set to "1" may report the end of a station busy condition as specified in 8.1.3.

See 6.1, 6.5.2, and 8.2.1 for description of P/F bit operation.

7.2 Supervisory Format (S) Commands/Responses

Supervisory (S) commands/responses are used to perform basic supervisory link control functions such as I frame acknowledgement, polling, temporary interruption of information (I/UI) transfer, and error recovery.

Frames with the S format do not contain an information field. Therefore, a station does not increment its send variable (S) upon the transmission of an S format frame nor does it increment its receive variable (R) upon accepting an S format frame.

The encoding of the S command/response control field is as follows:

```
                         Supervisory Format
                      <----Control Field--------------->|

   First Bit Transmitted
                        |
                        |
                        v

  Control Field Bits:   1   2   3   4   5   6    7   8
                      +--------------------------------+
                      | 1   0  |  S   |P/F |   N(R)    |
                      +--------------------------------+
                          |       |      |        |
                          |       |      |        |
                          v       |      |        v
                                  |      |
                     Supervisory  |      |     Receive Sequence
                       Format     |      |     Number Modulo 8
                                  |      |
                                  |      v
                                  |  Command: Poll
                                  |  Response: Final
                                  |
                                  v
```

Commands		Responses
RR - Receive ready	00	RR - Receive ready
RNR - Receive not ready	10	RNR - Receive not ready
REJ - Reject	01	REJ - Reject
SREJ - Selective reject	11	SREJ - Selective reject

For extended control field format see 5.2.2.

An S frame contains an N(R), receive sequence number, which indicates the sequence number of the next expected I frame (i.e., all received I frames numbered up to and including N(R)-1 are accepted). See 6.1, 6.5.2, and 8.2.1 for a description of the P/F bit operation.

7.2.1 Receive Ready (RR) Command/Response

Receive ready (RR) is used by a station to: (1) indicate it is ready to receive an I frame and (2) acknowledge I frames numbered up to and including N(R)-1.

The primary/combined station may use the RR command with the P bit set to "1" to solicit responses from (poll) a secondary/combined station.

An RR frame is one way to report the end of a station busy condition. See 8.1.3.

7.2.2 Receive Not Ready (RNR) Command/Response

Receive not ready (RNR) is used by a station to indicate a "busy" condition; i.e., the temporary inability to accept additional incoming information (I or UI) frames. I frames numbered up to and including N(R)-1 are acknowledged. I frame N(R) and any subsequent I frames received, if any, are not acknowledged; the acceptance status of these frames will be indicated in subsequent exchanges.

The primary/combined station may also use the RNR command with the P bit set to "1" to obtain the receive status of a secondary/combined station. The secondary/combined station response will be a frame with the F bit set to "1". See 8.1, Busy Condition, for further details on RNR usage.

7.2.3 Reject (REJ) Command/Response

Reject (REJ) is used by a station to request retransmission of I frames starting with the frame numbered N(R). I frames numbered N(R)-1 and below are acknowledged. Additional I frames pending initial transmission may be transmitted following the retransmitted I frame(s).

Only one REJ exception condition, from a given station to another station, may be established at any given time; another REJ or SREJ may not be transmitted (i.e., actioned) until the first REJ exception condition has been cleared at the sender.

The REJ exception condition is cleared (reset) upon acceptance of an I frame with an N(S) number equal to the N(R) of the REJ command/response or after a timeout has occurred.

An REJ is one way to report the end of a station busy condition. See 8.1.3.

See 8.2 for sequence error recovery protocols.

7.2.4 Selective Reject (SREJ) Command/Response

Selective reject (SREJ) is used by a station to request retransmission of the single I frame numbered N(R). I frames up to and including N(R)-1 are acknowledged.

The SREJ exception condition is cleared (reset) upon acceptance of an I frame with an N(S) number equal to the N(R) of the SREJ command/response.

After a station transmits a SREJ it may not transmit another SREJ (except for a SREJ with P or F bit set to "1" and with N(R) equal to the N(R) of the first SREJ; see 8.2.3) or another REJ for an additional sequence error until the first SREJ error condition has been cleared or a time-out has occurred. (This is because such a transmission would acknowledge as correctly received all I frames up to and including N(R)-1, where N(R) is the sequence number in the second SREJ or REJ.)

I frames that may have been transmitted following the I frame indicated by the SREJ command/response are not retransmitted as the result of receiving an SREJ. Additional I frames awaiting initial transmission may be transmitted following the retransmission of the specific I frame requested by the SREJ.

An SREJ is one way to report the end of a station busy condition. See 8.1.3.

See 8.2 for sequence error recovery protocols.

7.3 Unnumbered Format (U) Commands/Responses

Unnumbered (U) commands and responses are used to extend the number of link supervisory functions. U frames do not increment the send variable (S) at the transmitting station or increment the receive variable (R) at the receiving station. Five "modifier" bits are defined which allow up to 32 additional command functions and 32 additional response functions.

The encoding of the U command/response control field is as follows:

```
                          |                                 |
                          |<------Unnumbered Format-------->|
                                  Control Field

     First Bit
     Transmitted------+
                      |
                      |
                      v
     Control
     Field Bits:      1    2    3    4    5    6    7    8
                   +-------------------------------------+
                   |  1    1 |  M    M|  P/F |  M    M    M|
                   +-------------------------------------+
                        |         |        |          |
                        |         |        |          |
                        v         +--------|----------|
                                           |          v
              Unnumbered Format            |
                                           |    5 "Modifier" Bits
                                           |
                                           v

                                        Command: Poll
                                        Response: Final
```

For extended control field format see 5.2.2.

See 6.1, 6.5.2, and 8.2.1 for description of the P/F bit operation.

7.4 Unnumbered Format Commands

Unnumbered format commands are grouped according to the function performed:

(1) Mode-setting commands: SNRM, SARM, SABM, SNRME, SARME, SABME, SIM, DISC

(2) Information transfer commands: UI, UP

(3) Recovery commands: RSET

(4) Miscellaneous commands: XID

(5) Nonreserved commands: 4 encodings

The following U format commands are defined; other commands may be defined in the future if required. All bit encodings not defined are reserved for future standard assignment.

First Bit Transmitted

Control Field Bits

1	2	3	4	5	6	7	8	
1	1	0	0	P	0	0	1	SNRM command
1	1	1	1	P	0	0	0	SARM command
1	1	1	1	P	1	0	0	SABM command
1	1	1	1	P	0	1	1	SNRME command
1	1	1	1	P	0	1	0	SARME command
1	1	1	1	P	1	1	0	SABME command
1	1	1	0	P	0	0	0	SIM command
1	1	0	0	P	0	1	0	DISC command
1	1	0	0	P	0	0	0	UI command
1	1	0	0	P	1	0	0	UP command
1	1	1	1	P	0	0	1	RSET command
1	1	1	1	P	1	0	1	XID command
1	1	0	1	P	0	0	0	Nonreserved command
1	1	0	1	P	0	0	1	Nonreserved command
1	1	0	1	P	0	1	0	Nonreserved command
1	1	0	1	P	0	1	1	Nonreserved command

For extended control field format see 5.2.2.

See 6.1, 6.5.2, and 8.2.1 for description of the P bit operation.

The mode-setting commands, RSET, and the XID command form a set of commands which require a specific response from a secondary/combined station. The response to a command of this set takes precedence over other responses which may be pending. If more than one command of this set is received prior to a respond opportunity, a single response is transmitted that is referenced to the first such command received; any additional commands of the set are monitored only to detect the next respond opportunity.

NOTE: It is recommended that the primary/secondary station transmitting one of the commands in this set provide a respond opportunity for the remote station with each transmitted command (e.g., issue the command with the P bit set to "1").

In the case of TWA operation, following the receipt of one of these U commands, a secondary/combined station is restricted to transmitting a single response frame. In the case of TWS operation a secondary/combined station which is transmitting at the time of the receipt of one of these U commands will initiate transmission of a single response frame at the first respond opportunity. The secondary/combined station may continue transmission following return of the response as appropriate to its respond opportunity.

7.4.1 Mode-Setting Commands

Mode-setting commands are transmitted by the primary/combined station in order to reset or change the mode of the addressed secondary/combined station. Once established a mode remains in effect at a secondary station until the next mode-setting command is accepted, and at a combined station until the next mode-setting command is either accepted or transmitted and acknowledged.

The SNRM, SARM, SABM, SNRME, SARME, SABME, SIM, and DISC commands require the secondary/combined station to acknowledge acceptance by responding with a single unnumbered acknowledgement (UA) frame at the first respond opportunity. The UA has the F bit set to "1" if the mode-setting command had the P bit set to "1". If other I, S, or U format commands are received following a mode-setting command and prior to a respond opportunity, they are monitored only to determine the respond opportunity.

In the case of the operational mode-setting command (SNRM, SARM, SABM, SNRME, SARME, SABME) the respond opportunity at the secondary station is determined by the command received (i.e., the mode to which the secondary/combined station is directed dictates when the response is transmitted). Unless a response to XID or RSET is pending, a secondary/combined station responds as follows to the receipt of a mode-setting command:

(1) Upon receipt of a SNRM or SNRME command with the P bit set to "1", the secondary station responds with a single UA frame with the F bit set to "1". Upon receipt of a SNRM or SNRME command with the P bit set to "0", the secondary station waits

  (a) until it receives a command with the P bit set to "1", in which case it responds with a single UA frame with the F bit set to "1"; or

  (b) until it receives a UP command (with the P bit set to "0"), in which case it responds with a single UA frame with the F bit set to "0".

(2) Upon receipt of a SARM or SARME command, with or without the P bit set to "1", the secondary station will transmit a single UA frame:

  (a) upon detection of an idle link state in TWA operation, or

  (b) at the earliest respond opportunity in TWS operation.

The UA frame will have the F bit set to "1" if the command has the P bit set to "1".

(3) Upon receipt of a SABM or SABME command, with or without the P bit set to "1", the combined station will transmit a single UA frame:

(a) upon detection of an idle link state in TWA operation, or

(b) at the earliest respond opportunity in TWS operation.

The UA frame will have the F bit set to "1" if the command has the P bit set to "1".

In the case of the nonoperational mode-setting commands (SIM or DISC) the secondary/combined station will respond with a single UA frame at its system-defined respond opportunity; i.e., a given secondary/combined station is system defined to always use the normal respond opportunity or the asynchronous respond opportunity for the UA response.

If the secondary/combined station cannot accept a mode-setting command, it will, at its first respond opportunity, transmit one of the responses, DM, FRMR, RD or RIM, as appropriate, indicating non-acceptance of the command.

NOTE: The protocol defined here requires that the primary/combined station restrict the transmission of U commands which require UA responses so that only one such command is outstanding (not acknowledged) to any given secondary/combined station at any given time. This eliminates the requirement for the secondary/combined station to queue responses and prevents any ambiguity regarding the meaning of the UA response.

7.4.1.1 Set Normal Response Mode (SNRM) Command

The SNRM command is used to place the addressed secondary station in NRM where all control fields are one octet in length. No information field is permitted with the SNRM command.

Upon acceptance of this command the secondary station send and receive variables are set to zero. The secondary station confirms acceptance of SNRM by transmission of a UA in the unextended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SNRM is one way to report the end of a primary station busy condition. See 8.1.3.

7.4.1.2 Set Asynchronous Response Mode (SARM) Command

The SARM command is used to place the addressed secondary station in ARM where all control fields are one octet in length. No information field is permitted with the SARM command.

Upon acceptance of this command the secondary station send and receive variables are set to zero. The secondary station confirms acceptance of SARM by the transmission of a UA response in the unextended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SARM is one way to report the end of a primary station busy condition. See 8.1.3.

7.4.1.3 Set Asynchronous Balanced Mode (SABM) Command

The SABM command is used to place the addressed combined station in ABM where all control fields are one octet in length. No information field is permitted with the SABM command.

Upon acceptance of this command the combined station send and receive variables are set to zero. The combined station confirms acceptance of SABM by the transmission of a UA response in the unextended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SABM is one way to report the end of a combined station busy condition. See 8.1.3.

7.4.1.4 Set Normal Response Mode Extended (SNRME) Command

The SNRME command is used to place the addressed secondary station in NRM where all control fields will be two octets in length as defined in 5.2.2. No information field is permitted with the SNRME command.

Upon acceptance of this command the secondary station send and receive variables are set to zero. The secondary station confirms acceptance of SNRME by transmission of a UA response in the extended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SARME is one way to report the end of a primary busy condition. See 8.1.3.

7.4.1.5 Set Asynchronous Response Mode Extended (SARME) Command

The SARME command is used to place the addressed secondary station in ARM where all control fields will be two octets in

length as defined in 5.2.2. No information field is permitted with the SARME command.

Upon acceptance of this command the secondary station send and receive variables are set to zero. The secondary station confirms acceptance of SARME by transmission of a UA response in the extended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SARME is one way to report the end of a primary busy condition. See 8.1.3.

7.4.1.6 Set Asynchronous Balanced Mode Extended (SABME) Command

The SABME command is used to place the addressed combined station in ABM where all control fields will be two octets in length as defined in 5.2.2. No information field is permitted with the SABME command.

Upon acceptance of this command the combined station send and receive variables are set to zero. The combined station confirms acceptance of SABME by transmission of a UA response in the extended control field format.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. Transmission of SABME is one way to report the end of a combined station busy condition. See 8.1.3.

7.4.1.7 Set Initialization Mode (SIM) Command

The SIM command is used to cause the addressed secondary/combined station to initiate a station-specified procedure(s) to initialize its link level control functions (e.g., accept a new program or update operational parameters). No information field is permitted with the SIM command.

The secondary/combined station confirms acceptance of SIM by transmission of a UA response. The respond opportunity and the control field format of the UA response are system defined.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged.

7.4.1.8 Disconnect (DISC) Command

The DISC command is used to perform a logical disconnect; i.e., to inform the addressed secondary/combined station that the transmitting primary/combined station is suspending operation with that secondary/combined station. In switched networks, this logical disconnect function at the data link level may serve to initiate a physical disconnect operation at the physical

interface level; i.e., to go "on-hook". No information field is permitted with the DISC command.

The secondary/combined station confirms acceptance of DISC by the transmission of a UA response. The respond opportunity and the control field format of the UA response is system defined. A secondary/combined station in ADM or NDM will transmit a DM response upon receiving a DISC command. A RIM response may be transmitted instead of DM under the system-defined conditions described in 6.3. The respond opportunity and control field format after receipt of DISC is system defined for any given secondary station. The respond opportunities are defined in 6.2.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged.

7.4.2 Unnumbered Information Transfer Commands

Unnumbered information transfer commands are used to exchange frames containing information.

7.4.2.1 Unnumbered Information (UI) Command

The UI command is used to transfer an information field to a secondary/combined station or group of secondary stations without impacting the send and receive variables. The information field is optionally present with the UI command. Reception of the UI frame is not sequence-number verified; therefore, the frame may be lost if a link exception occurs during transmission of the UI or the frame may be duplicated if an exception occurs during any reply to the UI. Examples of UI frame information are higher level status, operation interruption, temporal data (e.g., time-of-day), or link initialization parameters.

See Appendix B for additional explanatory information.

7.4.2.2 Unnumbered Poll (UP) Command

The UP command is used to solicit response frames from a single secondary/combined station (individual poll) or from a group of secondary stations (group poll), by establishing a logical operational condition that exists at each addressed station for one respond opportunity. (In the case of a group poll, the mechanism employed to control (schedule) the response transmissions (to avoid simultaneous transmissions) is considered to exist and is not defined in this standard.) Secondary stations receiving UP with a group address will respond in the same manner as when addressed with an individual address. The response frame(s) will contain the sending secondary/combined station individual address, plus N(S) and N(R) numbers as required by the particular responses. (The continuity of each

secondary/combined station N(S) will be maintained.) The UP command does not acknowledge receipt of any response frames that may have been previously transmitted by the secondary/combined station. No information field is permitted with the UP command.

A secondary/combined station which receives a UP with the P bit set to "1" will respond (at its respond opportunity and consistent with its mode of operation) with a frame which has the F bit set to "1".

A secondary/combined station which receives a UP with the P bit set to "0" may or may not respond; responses will have the F bit set to "0" in all response frames. A secondary/combined station will respond to a received UP which has the P bit set to "0" when (1) it has an I/UI frame(s) to send, (2) it has accepted but not acknowledged an I frame(s), (3) it has experienced an exception condition or change of status that has not been reported, or (4) it has a status to be reported (e.g., DM, FRMR, or optionally an appropriate frame to report a no traffic condition).

7.4.3 Unnumbered Recovery Command

The unnumbered recovery command is used to facilitate the link level exception condition recovery protocol.

7.4.3.1 Reset (RSET) Command

The RSET command is transmitted by a combined station to reset the receive state variable (R) and applicable FRMR conditions in the addressed combined station. No information field is permitted with the RSET command.

Upon acceptance of this command the station receive state variable (R) is set to zero. The combined station confirms acceptance of RSET by transmission of the UA response while remaining in the previously established operational mode. If the UA is received correctly, the initiating combined station resets its send state variable (S). Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged.

The RSET command will clear all frame rejection conditions except for an invalid N(R) condition in the addressed combined station. The RSET command may be sent by a combined station which detects an invalid N(R) instead of reporting such a frame rejection condition via a FRMR response.

7.4.4 Miscellaneous Commands

At this time there is only one command in the miscellaneous command group, and it is used to provide a means for the transfer

of station identification and status information.

7.4.4.1 Exchange Identification (XID) Command

The XID command is used to cause the addressed secondary/combined station to report its station identification and, optionally, to provide the station identification of the transmitting primary/combined station to the addressed secondary/combined station. An information field is optional with the XID command; if present the information field will be the station ID of the primary/combined station. The primary/combined station may use the global address if the unique address of the secondary/combined station is not known. A secondary/combined station in any mode receiving an XID command will transmit an XID response unless (1) a UA response is pending, (2) a FRMR condition exists, (3) a RIM condition exists, or (4) the XID command cannot be actioned in a disconnected mode.

7.4.5 Nonreserved Commands

Four nonreserved command code points are set aside to permit the implementer to define special system-dependent functions that do not have general applicability. Such special system-dependent functions are beyond the scope of this standard.

7.5 Unnumbered Format Responses

Unnumbered format responses are grouped according to the function performed:

(1) Responses to mode-setting and status requests: UA,DM,RIM
(2) Information transfer responses: UI
(3) Recovery responses: FRMR
(4) Miscellaneous responses: XID, RD
(5) Nonreserved responses: 4 encodings

First Bit Transmitted

Control Field Bits

1	2	3	4	5	6	7	8	
1	1	0	0	F	1	1	0	UA response
1	1	1	1	F	0	0	0	DM response
1	1	1	0	F	0	0	0	RIM response
1	1	0	0	F	0	0	0	UI response
1	1	1	0	F	0	0	1	FRMR response
1	1	1	1	F	1	0	1	XID response
1	1	0	0	F	0	1	0	RD response
1	1	0	1	F	0	0	0	Nonreserved response
1	1	0	1	F	0	0	1	Nonreserved response
1	1	0	1	F	0	1	0	Nonreserved response
1	1	0	1	F	0	1	1	Nonreserved response

For extended control field format see 5.2.2.

See 6.1, 6.5.2, and 8.2.1 for description of the F bit operation.

7.5.1 Responses to Mode-Setting and Status Requests

The UA, DM, and RIM responses are used by the secondary/combined station to request transmission of, or to respond to, the mode-setting commands of the primary/combined station; DM and RIM are additionally used to indicate secondary/combined station status.

7.5.1.1 Unnumbered Acknowledgement (UA) Response

The UA response is used to acknowledge the receipt and acceptance of the SNRM, SARM, SABM, SNRME, SARME, SABME, SIM, DISC, and RSET unnumbered commands defined in 7.4.1 and 7.4.3. The UA response is transmitted in the basic or the extended control field format as directed by the received unnumbered command. No information field is permitted with the UA response.

A UA response is one way to report the end of a station busy condition. See 8.1.3.

7.5.1.2 Disconnected Mode (DM) Response

The DM response is used to report that the secondary/combined station is in the logically disconnected state; i.e., the secondary/combined station is, by system definition, in NDM or ADM. See 6.3.

The DM response is sent by a secondary/combined station in NDM or ADM to request the remote primary/combined station to issue a mode-setting command or, if sent in response to the reception of a mode-setting command, to inform the remote primary/combined

station that the transmitting secondary/combined station is still in NDM/ADM and cannot action the mode-setting command. On a switched network where the call is initiated by a secondary/combined station, DM is sent to request a mode-setting command. On a nonswitched line a secondary/combined station in ADM may send the DM response at any respond opportunity. No information field is permitted with the DM response.

A secondary/combined station in NDM or ADM will monitor received commands (other than those that reset the disconnected mode) only to detect a respond opportunity in order to (re)transmit DM (or RIM if initialization is required); i.e., no I/UI transmissions are exchanged until the disconnected mode is reset by the acceptance of SNRM, SARM, SABM, SNRME, SARME, SABME, OR SIM.

See Appendix C, Example 5.5.

7.5.1.3 Request Initialization Mode (RIM) Response

The RIM response is used to request the SIM command. A secondary/combined station which has established a RIM condition will monitor any subsequently received commands (other than SIM) only to detect a respond opportunity to (re)transmit RIM or to send DM; i.e., no command transmissions are accepted until the RIM condition is reset by the receipt of SIM. No information field is permitted with the RIM response.

7.5.2 Unnumbered Information Transfer Response

The unnumbered information transfer response is used to exchange frames containing information.

7.5.2.1 Unnumbered Information (UI) Response

The UI response is used to transfer an information field to a primary/combined station without impacting the send and receive variables. The information field is optionally present with the UI response. Reception of the UI frame is not sequence-number verified; therefore, the frame may be lost if a link exception condition occurs during transmission of the UI, or duplicated if an exception occurs during any reply to the UI. Examples of UI frame information are higher level status, operation interruption, temporal data, and link initialization parameters.

7.5.3 Unnumbered Recovery Response

The unnumbered recovery response is used to facilitate the link-level exception condition recovery protocol.

7.5.3.1 Frame Reject (FRMR) Response

The FRMR response is used to report an error condition that is not recoverable by retransmission of the identical frame, such as:

(1) the receipt of a control field that is invalid or not implemented.

(2) the receipt of an I/UI frame with an information field which exceeded the maximum established length.

(3) the receipt of an invalid N(R) number from the remote primary/combined station.

NOTE: An invalid N(R) is defined as a number which points to an I frame which has previously been transmitted and acknowledged, or to an I frame which has not been transmitted and is not the next sequential I frame pending transmission.

A secondary/combined station in a disconnected mode (NDM or ADM) will not establish a frame reject exception condition.

FRMR Basic Information Field

A basic information field, which immediately follows the basic control field, is returned with this response to provide the reason for the frame reject response. The format for the basic information field is as follows:

```
|                                                                    |
|                                                                    |
|<--------------------Basic Information Fields--------------------> |
|┌----First Bit                                                      |
|↓    Transmitted                                                    |
|                                                                    |
|1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20|

┌--------------------------------------------------------------------┐
|Rejected              |   |          |      |         |             |
|Basic Control Field   | 0 |   N(S)   | C(R) | N(R)    | W  X  Y    Z|
└--------------------------------------------------------------------┘
```

where:

Rejected Basic Control Field is the control field of the received frame which caused the frame reject exception condition.

N(S) is the current send variable (S) at the station transmitting the FRMR response.

C/R is set to "1" if the frame which caused the FRMR was a response frame, or is set to "0" if the frame that caused the FRMR was a command frame.

N(R) is the current receive variable (R) at the station transmitting the FRMR response.

W set to "1" indicates that the control field received and returned in bits 1 through 8 was invalid or not implemented.

X set to "1" indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this frame. Bit W must be set to "1" in conjunction with this bit.

Y set to "1" indicates that the information field received exceeded the maximum established capacity of the secondary/combined station.

Z set to "1" indicates that the control field received and returned in bits 1 through 8 contained an invalid N(R) number.

If required, the information field associated with the FRMR may be padded with zero bits so as to end on any convenient, mutually agreed upon character, byte, word or machine-dependent boundary.

FRMR may have bits W, X, Y, and Z all set to zero; however the cause for frame reject shall be as defined in (1), (2), and (3) above.

See also 8.4, Frame Reject Exception Condition.

FRMR Extended Information Field

The format for the extended information field, which immediately follows the extended control field (see 5.2.2), and which is returned with the FRMR response, is as follows:

```
|                                                                  |
|                                                                  |
|<---------------------------Extended Information----------------->|
|                              Field Bits                          |
|First Bit Transmitted                                             |
| ↓                                                                |
|                                                                  |
|                                                                  |
  1                 16   17 18          24  25 26           32 33     36
--------------------------------------------------------------------
| Rejected Extended  |  0 |           N(S) |C/R|      N(R)     | WXYZ  |
|   Control Field    |    |                |   |               |       |
--------------------------------------------------------------------
```

7.5.4 Miscellaneous Responses

7.5.4.1 Exchange Identification (XID) Response

The XID response is used to reply to an XID command. An information field containing the identification of the transmitting secondary/combined station is optionally present with the XID response. A secondary/combined station receiving an XID command will action the XID in any mode unless (1) a UA is pending, (2) a FRMR condition exists, (3) a RIM condition exists, or (4) the XID can not be actioned in a disconnected mode.

On switched networks when the secondary/combined station is constrained to send first, it may use the XID response, which may contain an optional information field, to request an XID exchange. See Section 10, Switched Network Conventions.

7.5.4.2 Request Disconnect (RD) Response

The RD response is used to indicate to the remote primary/combined station that the transmitting secondary/combined station is requesting that it be placed in a logically disconnected mode (NDM or ADM) by the receipt of a DISC command. RD may be sent asynchronously if the secondary/combined station is in ARM/ABM, or if it is in NRM as a response to any command with the P bit set to "1" or in response to a UP command with the P bit set to "0". See 7.4.2.2. A secondary/combined station which has sent an RD response and receives any non-DISC frame(s) must accept the command frame(s) if it is able to do so. If the secondary/combined station accepts the non-DISC command frame(s), it follows the normal ADCCP elements of procedures to respond to the primary/combined station commands. Secondary/combined station acceptance of non-DISC frames after having issued an RD response cancels the RD response. If the secondary/combined station still wants to be placed in disconnected mode (NDM or ADM), it must reissue the RD response. A secondary/combined station which cannot accept non-DISC command frames due to internal problems may respond with RD again. No information field is permitted with the RD response.

7.5.5 Nonreserved Responses

Four nonreserved response code points are set aside to permit the implementer to define special system-dependent functions that do not have general applicability. Such special system-dependent functions are beyond the scope of this standard.

8. EXCEPTION CONDITION REPORTING AND RECOVERY

This section specifies the procedures to be observed to effect recovery following the detection or occurrence of an exception

condition at the link level. Exception conditions described are those situations that may occur as the result of transmission errors, station malfunction, or operational situations.

8.1 Busy Condition

A busy condition occurs when a station temporarily cannot receive or continue to receive I or UI frames due to internal constraints; e.g., when a station cannot receive due to buffering limitations. The busy condition is reported by the transmission of an RNR frame with the N(R) number of the next I frame that is expected. Traffic pending transmission at the busy station may be transmitted prior to or following the RNR. The continued existence of a busy condition must be reported by retransmission of RNR at each P/F frame exchange. See 8.1.3, Clearing Busy Condition.

8.1.1 Secondary/Combined Station Receipt of RNR Command

A secondary station transmitting TWS in NRM will upon receipt of an RNR command cease transmission at the earliest possible time. The frame in process may be completed or aborted; however, transmission must be terminated with the F bit set to "1" (see Example 5.2.1, Appendix C). The secondary station may resume transmission of I or UI frames, or both, at the next poll command (an RR, REJ, SREJ, or I command frame with the P bit set to "1").

A secondary/combined station transmitting TWS in ARM/ABM will, upon receipt of an RNR, cease transmitting I or UI frames at the earliest possible time by completing or aborting the frame in process. If the RNR command frame was received with the P bit set to "1" the secondary/combined station must transmit a frame with the F bit set to "1". See Examples 5.4.1 and 5.4.3 in Appendix C. The secondary/combined station must perform a time-out operation before resuming asynchronous transmission of I or UI frames unless the busy condition is reported as cleared by the remote station.

8.1.2 Primary/Combined Station Receipt of RNR Response

Primary/combined station receipt of an RNR response indicates that the transmitting secondary/combined station has a busy condition.

8.1.3 Clearing Busy Condition

The busy condition is cleared at the station which transmitted the RNR when the internal constraint ceases.

Clearance of the busy condition is reported to the remote station by transmission of an RR, REJ, SREJ, SARM, SARME, SNRM, SNRME, SABM, SABME, or UA frame (with or without the P/F bit set to "1"). A busy condition is also cleared when a primary station

transmits an I frame with the P bit set to "1", or when a secondary/combined station transmits an I frame with the F bit set to "1".

8.2 N(S) Sequence Error

An N(S) sequence exception is established in the receiving station when an I frame that is received error free (no FCS error) contains an N(S) sequence number that is not equal to the receive variable (R) at the receiving station. The receiving station does not acknowledge (does not increment its receive variable (R)) the frame causing the sequence error, or any I frames which may follow, until an I frame with the correct N(S) number is received. Unless SREJ is to be used to recover from a given sequence error, the information field of all I frames received whose N(S) does not equal the receive variable (R) will be discarded. See 8.2.3 for SREJ recovery.

A station which receives one or more I frames having sequence errors, but which are otherwise error free, will accept the control information contained in the N(R) field and the P/F bit to perform link control functions; e.g., to receive acknowledgement of previously transmitted I frames (via the N(R)); to cause a secondary/combined station to respond (P bit set to "1"); and in NRM to detect that the secondary station will terminate transmission (F bit set to "1"). The retransmitted frame may contain an N(R) value or P/F bit information, or both, that have been updated and are therefore different from those contained in the originally transmitted I frames.

The means specified in 8.2.1 through 8.2.4 are available for initiating the retransmission of lost or errored I frames following the occurrence of a sequence error.

8.2.1 Checkpoint Recovery

Checkpoint recovery is based on a checkpoint cycle. For a primary/combined station a checkpoint cycle begins with the transmission of a frame with a P bit set to "1" and ends either (1) with the receipt of a frame with an F bit set to "1" or (2) when the response timer expires. For a secondary station, a check point cycle begins with the transmission of a frame with the F bit set to "1" and ends with the receipt of a frame with a P bit set to "1".

When a primary/combined station receives a frame with the F bit set to "1" or when a secondary station receives a frame with the P bit set to "1", the station will initiate retransmission of all unacknowledged I frames with sequence numbers less than the send variable (S) at the time the last frame with the P bit set to "1" (primary/combined) or frame with the F bit set to "1" (secondary) was transmitted. Retransmission starts with the lowest numbered unacknowledged I frame. I frames are retransmitted sequentially.

New frames may be transmitted if they become available. Such retransmission of I frames is known as checkpoint retransmission.

Note that in balanced operation either combined station may initiate a checkpointing cycle independently of the other by the transmission of a frame with the P bit set to "1". Therefore, since two independent checkpointing cycles may be in process simultaneously, a combined station will not initiate checkpoint retransmission upon the receipt of a frame with the P bit set to "1".

To prevent duplicate retransmissions, checkpoint retransmission of a specific I frame (same N(R) in the same numbering cycle) is inhibited for the current checkpoint cycle if during the checkpoint cycle:

(1) A primary station has previously received and actioned a REJ with the F bit set to "0".

(2) A secondary station has previously received and actioned a REJ with the P bit set to "0".

(3) A combined station has previously received and actioned a REJ with the P bit set to "0" or "1" or an F bit set to "0".

If an SREJ with a P/F bit set to "1" is received, checkpoint retransmission is not initiated.

Checkpoint retransmission is also inhibited if an unnumbered format frame with the P/F bit set to "1" is received because in such a case there is no N(R) for checkpoint reference.

Finally checkpoint retransmission is inhibited if, after sending a frame with the P/F bit set to "1", a station receives an acknowledgement to that frame before the next checkpoint occurs.

8.2.2 REJ Recovery

The REJ command/response is primarily used to initiate an exception recovery (retransmission) following the detection of a sequence error earlier than is possible by checkpoint recovery; e.g., in two-way simultaneous information transfer if REJ is immediately transmitted upon detection of a sequence error it is not necessary to wait for a frame with P/F bit set to "1".

Only one "sent REJ" exception condition, from a given station to another given station, is established at a time. A "sent REJ" exception is cleared when the requested I frame is received, when a time-out function expires, or when a checkpoint cycle that was initiated concurrent with or following the transmission of REJ is completed. When the station perceives by time-out or by the checkpointing mechanism that the requested I frame will not be

received, because either the requested I frame or the REJ was in error or lost, the REJ may be repeated.

A station receiving REJ initiates sequential (re)transmission of I frames starting with the I frame indicated by the N(R) contained in the REJ frame.

If (1) retransmission beginning with a particular frame occurs due to checkpointing (see 6.5.2 and 8.2.1), and (2) a REJ is received before a checkpoint cycle completion which would also start retransmission with the same particular frame (as identified by the N(R) in the REJ), the retransmission resulting from the REJ shall be inhibited.

8.2.3 SREJ Recovery

The SREJ command/response is primarily used to initiate more efficient error recovery by requesting the retransmission of only a single I frame following the detection of a sequence error rather than the retransmission of the I frame requested plus all additional I frames which may have been subsequently transmitted.

NOTE: To improve transmission efficiency it is recommended that the SREJ command/response be transmitted as the result of the detection of a sequence error where only a single I frame is missing, as determined by receipt of the out-of-sequence N(S).

When an I frame sequence error is detected, the SREJ is transmitted at the earliest possible time. When a station sends an SREJ with the P bit set to "0" (primary station), with the F bit set to "0" (secondary/combined station), or with the P bit set to "0" or "1" (combined station), and the "sent SREJ" condition is not cleared when the station is ready to issue the next frame with the P bit (primary) or the F bit (secondary/combined) set to "1", the station sends an SREJ with the same N(R) as the original SREJ with the P/F bit set to "1".

Since a frame sent with the P bit (primary station) or the F bit (secondary/combined station) set to "1" has the potential of causing checkpoint retransmission, a station will not send an SREJ with the same N(R) (same value and same numbering cycle) as that of the previously sent frame with the P bit (primary station) or the F bit (secondary/combined station) set to "1" until the current checkpoint cycle ends.

Only one "sent SREJ" exception condition from a given station to another given station is established at a time. A "sent SREJ" exception condition is cleared when the requested I frame is received, when time-out function expires, or when a checkpoint cycle that was initiated concurrent with or following the transmission of SREJ is completed. When the station perceives by time-out or by the checkpointing mechanism that the requested I frame will not be received, because either the requested I frame

or the SREJ was in error or lost, the SREJ may be repeated.

When a station receives and actions an SREJ with the P bit (secondary station) or F bit (primary/combined station) set to "0" or with the P bit set to "0" or "1" (combined station), it will inhibit the actioning of the next SREJ if the SREJ has the P bit (secondary station) or F bit (primary/combined station) set to "1" and has the same N(R) (i.e., has the same value and same numbering cycle) as the original SREJ.

8.2.4 Time-Out Recovery

In the event a receiving station, due to a transmission error, does not receive (or receives and discards) a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an out-of-sequence exception and, therefore, will not transmit SREJ/REJ. The station which transmitted the unacknowledged I frame(s) shall, following the completion of a system-specified time-out period, take appropriate recovery action to determine the sequence number at which retransmission must begin.

NOTE: It is recommended that a station which has timed out waiting for a response not retransmit all unacknowledged frames immediately. A secondary station in ARM should, in this time-out case, either retransmit its last single frame or transmit new frames if they are available. A primary/combined station may enquire about status with a supervisory frame.

To account for possible retransmissions after time-out, a receiving station should not set a SREJ condition when it receives an I frame with an N(S) one less than its receive variable (R).

If a station does retransmit all unacknowledged I frames after a time-out, it must be prepared to receive a subsequent REJ frame with an N(R) greater than its send variable (S).

8.3 FCS Error

Any frame with an FCS error will not be accepted by the receiving station and will be discarded. At the secondary/combined station no action will be taken as the result of that frame.

8.4 Frame Reject Exception Condition

A frame reject exception condition is established upon the receipt of an error-free frame which contains an invalid or unimplemented control field, an invalid N(R), or an information field which has exceeded the maximum established storage capability.

If a frame reject exception condition occurs in a primary station, or is reported to the primary station by a FRMR

response, recovery action will be taken by the primary station. This recovery action includes the transmission of an implemented set mode command. Higher level functions may also be included in the recovery.

At the secondary station this exception condition is reported by transmitting a FRMR response to the primary station for appropriate action. Once a secondary station has established a FRMR exception, any additional commands (other than those that reset the FRMR exception condition) subsequently received are examined only with regard to the state of the N(R) and the P bit; i.e., only to update the acknowledgement of I frames previously transmitted and to detect a respond opportunity to retransmit FRMR. No additional transmissions are accepted or actioned until the condition is reset by the receipt of an implemented mode-setting command.

If a frame reject exception condition occurs in a combined station, the station will either:

(1) Take recovery action without reporting the condition to the remote combined station, or

(2) Report the condition to the remote combined station with a FRMR response. The remote station will then be expected to take recovery action; if, after waiting an appropriate time, no recovery action appears to have been taken, the combined station reporting the frame reject exception condition may take recovery action.

Recovery action for balanced operation includes the transmission of an implemented mode-setting or RSET command, as appropriate. Higher level functions may also be involved in the recovery.

8.5 Mode-Setting Contention

A mode-setting contention situation exists when a combined station issues a mode-setting command and, before receiving an appropriate response (UA or DM), receives a mode-setting command from the remote combined station. Contention situations shall be resolved in the following manner (see Appendix C, Example 8.5):

(1) When the send and receive mode-setting commands are the same, each combined station shall send an UA response at the earliest respond opportunity. Each combined station shall either enter the indicated mode immediately or defer entering the indicated mode until receiving an UA response. In the latter case, if the UA response is not received, (a) the mode may be entered when the response timer expires, or (b) the mode-setting command may be reissued.

(2) When the mode-setting commands are different, each

combined station shall enter ADM and issue a DM response at the earliest respond opportunity. In the case of DISC contention with a different mode-setting command no further action is required. In the case of contention between SABM and SABME commands, the combined station sending SABME shall have priority in attempting link establishment after the DM responses.

9. TIME-OUT FUNCTIONS

Time-out functions are used to detect that a required or expected acknowledging action or response to a previously transmitted frame has not been received. Expiration of the time-out function shall initiate appropriate action, e.g., error recovery or reissuance of the P-bit. The duration of time-out functions is system dependent and subject to bilateral agreement.

The time-out functions specified in 9.1 and 9.2 represent the minimum requirements and do not preclude other time-out functions.

9.1 Normal Respond Opportunity

The primary station transmitting a command with the P bit set to "1" or UP with the P bit set to "0", anticipates a response and, therefore, starts a time-out function. The time-out function shall automatically cease upon receipt of the expected response.

9.2 Asynchronous Respond Opportunity

The primary/combined station provides a time-out function to determine that a response frame with F bit set to "1" to a command frame with the P bit set to "1" has not been received. The time-out function shall automatically cease upon receipt of a valid frame with the F bit set to "1".

A primary/combined station which has no P bit outstanding, and which has transmitted one or more frames for which responses are anticipated, must start a time-out function to detect the no-response condition.

The secondary/combined station shall provide a time-out function to determine that a command frame has not been received acknowledging the receipt of an unsolicited response frame(s).

See 6.2.2 and 8.2.4.

10. SWITCHED NETWORK CONVENTIONS

Stations connected to a switched communications network may be capable of operation as one type of station only (e.g., a primary

station, a secondary station, or a combined station); or the station may be configurable as (one at a time) more than one of these types. The capabilities of the called station must be known at the calling station and the calling station must operate accordingly. If the called station is configurable it will:

(1) Implement the XID command and response, and

(2) Determine which station type (primary, secondary, or combined) to invoke by recognition of either the remote station address or identification (XID).

The calling or called station will initate the transmission interchange first depending on the characteristics of the transmission network. When initiated by the secondary station a single unsolicited supervisory or unnumbered response is sent. When initiated by the primary/combined station, any appropriate command with an appropriate address is sent. See Figure 10-1.

Called Station \ Calling Station	Primary Station	Secondary Station	Combined Station	Configurable Station
Primary Station	NA	S, P	NA	S, P
Secondary Station	P, S	NA	NA	P, S
Combined Station	NA	NA	C, C	C, C
Configurable Station	P, S	S, P	C, C	P/S/C, P/S/C

P = Primary station
S = Secondary station
C = Combined station
P/S/C = Primary or secondary or combined station, or all three
NA = Not applicable

Figure 10-1

Assumed Primary/Secondary/Combined Roles on Switched Network

11. CLASSES OF PROCEDURES

All classes of procedures use the two frame formats defined in Section 3, Frame Structure. In addition, all procedures assume that the links include primary and secondary stations or combined stations. Primary stations transmit commands (in frames with or without information), and secondary stations receive the command frames and transmit responses (in frames with or without information). Combined stations transmit and receive commands and responses (in frames with or without information). The primary/combined station is responsible for determining which commands to send, within the constraints of this standard.

Procedure differences based on overall system consideration (e.g., network configuration, traffic management, etc.) are accommodated by defining three modes of operation -- asynchronous, normal, and balanced-- and by defining three classes of procedures that utilize the capabilities of these modes together with the exception recovery characteristics specified within this standard. Optional functions are defined to provide additional capabilities. Individual classes implement a prescribed subset of the commands and responses defined in Section 7, and include P/F recovery as a minimum capability as defined in 6.1, 6.5.2, and 8.2.1.

11.1 Classes of Procedures

The three classes of procedures are composed of:

(1) Three types of stations: primary stations, secondary stations, and combined stations

(2) Two types of configurations: unbalanced (for primary and secondary stations) and balanced (for combined stations)

(3) Two types of respond opportunity: normal and asynchronous

Designation	Class of Procedures Description
UA	Unbalanced, asynchronous response mode, modulo 8
UN	Unbalanced, normal response mode, modulo 8
BA	Balanced, asynchronous balanced mode, modulo 8

Classes UA and UN can be used on either unbalanced or symmetric configurations. Class BA can be used on balanced configurations. See 2.2.

11.1.1 Unbalanced/Symmetric Configuration

Basic Repertoire of Commands and Responses

Commands	Responses
I	I
RR	RR
RNR	RNR
	FRMR
*SXXM	UA
DISC	DM

*SXXM command is SARM for UA class
SNRM for UN class

11.1.2 Balanced Configuration

Basic Repertoire of Commands and Responses

Commands	Responses
I	I
RR	RR
RNR	RNR
	FRMR
SABM	UA
DISC	DM
RSET	

11.2 Optional Functions

Optional functions are achieved by the addition or deletion of commands, responses, or capabilities to or from those present in any basic class of procedures.

Option	Functional Description	Required Change
1	Provides the ability to:	
	(a) exchange identification of stations. See 7.4.4.1 and 7.5.4.1.	Add command: XID Add response: XID
	(b) request logical disconnection. See 7.5.4.2.	Add response: RD
2	Provides the capability for more timely reporting of N(S) sequence errors to improve TWS performance. See 7.2.3.	Add command: REJ Add response: REJ

3	Provides the capability for more efficient recovery from N(S) sequence errors by requesting retransmission of a single I frame. See 7.2.4.	Add command: SREJ Add response: SREJ
4	Provides the ability to exchange information fields without impacting the send and receive variables. See 7.4.2.1 and 7.5.2.1.	Add command: UI Add response: UI
5	Provides the ability to initialize remote stations and the ability to request initialization. See 7.4.1.7 and 7.5.1.3.	Add command: SIM Add response: RIM
6	Provides the ability to perform unnumbered group polling as well as unnumbered individual polling. See 7.4.2.2.	Add command: UP
7	Provides for greater than single octet addressing. See 4.3.	Use extended addressing format in lieu of basic addressing format.
8	Limits the procedure to allow I frames to be commands only.	Delete response: I
9	Limits the procedure to allow I frames to be responses only.	Delete command: I
10	Provides the ability to use extended sequence numbering (modulo 128). See 5.2.2.	Use extended control field format in lieu of basic control field format. Use SXXME in lieu of SXXM.
11	Removes the ability to reset the send and receive variables associated with only one direction of information flow.	Delete command: RSET

11.3 Consistency of Classes of Procedures

Figure 11-1 gives a summary of the basic command/response repertoire of the one balanced and two unbalanced classes of procedures, and the commands/responses of the optional functions. In the unbalanced classes the primary station command repertoire

is listed on the left side of each class and the secondary station response repertoire is listed on the right side. As seen in the figure, the basic repertoire of all classes of procedures is identical with the exception of a unique mode-setting command for each class and the RSET command, which is used in the balanced class only. This repertoire consistency facilitates the inclusion of multiple classes of procedures in a station that is configurable.

11.4 Implementation of Classes of Procedure

A station conforms to a given class of procedures if it implements the basic repertoire of that class. To implement (see Appendix A definition) a class of procedures (or optional functions) means that:

(1) A primary station has the ability to receive all responses in the class of procedures basic repertoire (or optional functions).

(2) A secondary station has the ability to receive all commands in the class of procedures basic repertoire (or optional functions).

(3) A combined station has the ability to receive all commands and responses in the class of procedures basic repertoire (or optional functions).

11.5 Method of Indicating Classes and Optional Functions

Classes of procedures and the optional functions are indicated by specifying the mnemonic designation for the desired class and the number(s) of the accompanying optional functions.

Class UN,1,2,6 is the unbalanced, normal response mode class of procedures with the optional functions for identification and request disconnect (XID,RD), improved TWS performance (REJ), and unnumbered polling (UP).

Class BA,2,3,10 is the balanced, asynchronous balanced mode class of procedures with the optional functions for improved TWS performance (REJ), single frame retransmission (SREJ), and extended sequence numbering (modulo 128).

Class UA,1,5 is the unbalanced, asynchronous response mode class of procedures with the optional functions for identification and request disconnect (XID,RD) and initialization (SIM,RIM).

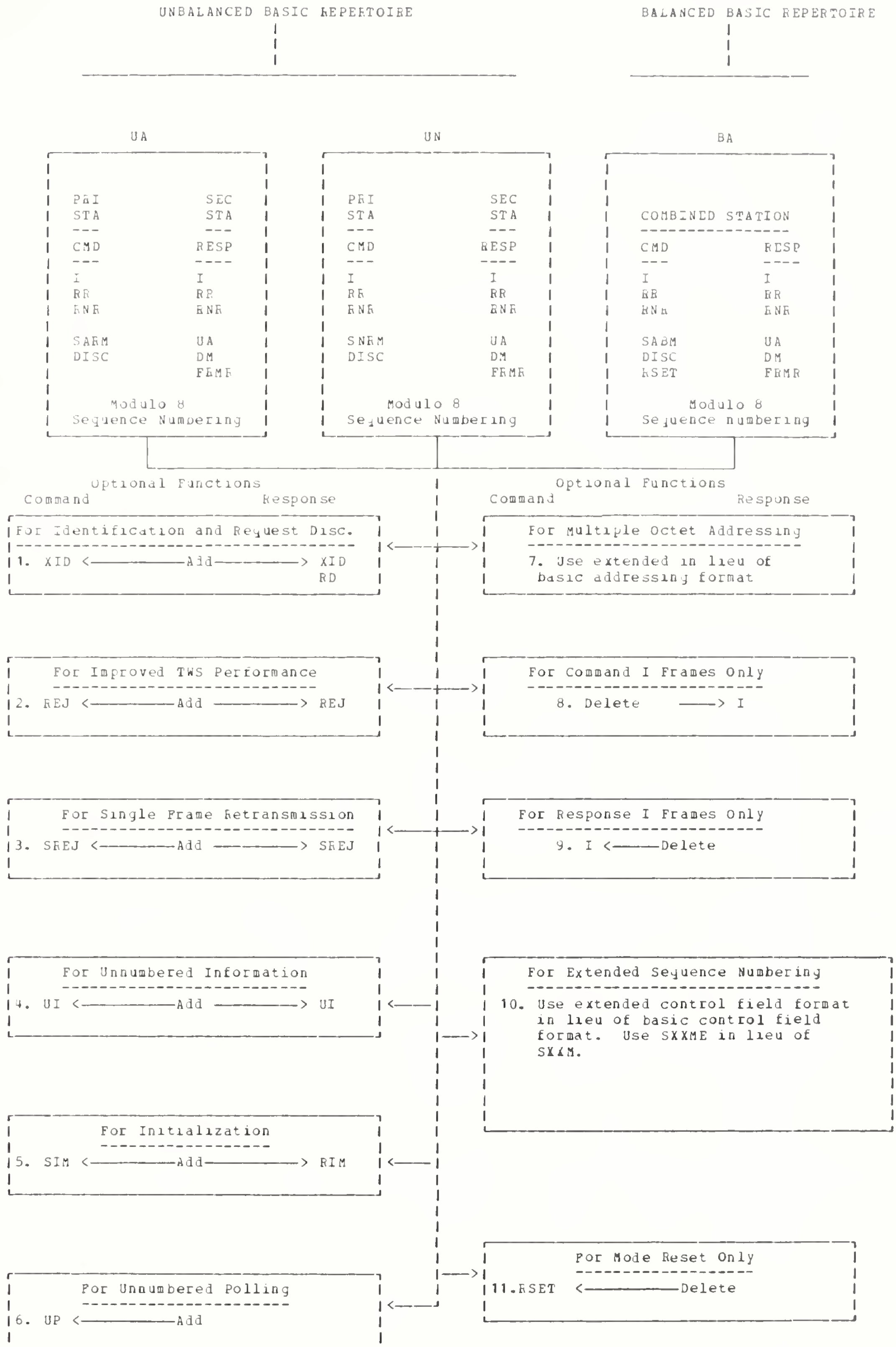


Figure 11-1

Basic Classes of Procedures and Their Optional Functions

12. FRAME CHECK SEQUENCE (FCS) GENERATION AND CHECKING

This section specifies the FCS generation and checking requirements. These requirements are formulated to detect frame length changes due to erroneous addition or deletion of zero bits at the end of the frame as well as to detect errors introduced within the frame.

12.1 FCS Generation

The equations for FCS generation are:

$$\frac{X^{16}\ G(X)^{k} + X\ L(X)}{P(X)} = Q(X) + \frac{R(X)}{P(X)}$$

$$FCS = L(X) + R(X) = \overline{R(X)}$$

The arithmetic is modulo 2

$L(X) = X^{15} + X^{14} + X^{13} + X^{12} + X^{11} + X^{10} + X^{9} + X^{8} + X^{7} + X^{6} + X^{5} + X^{4} + X^{3} + X^{2} + X^{1} + 1$

$R(X)$ = The remainder which is of degree less than 16

k = The number of bits represented by $G(X)$

$P(X)$ = The CCITT V.41 generator polynomial $(X^{16} + X^{12} + X^{5} + 1)$

$G(X)$ = The message polynomial, which includes the contents of the address, control, and information fields, excluding the zero bits inserted for transparency (see 3.7).

The generation of the remainder $R(X)$ differs from that used in conventional check sequence generation by the presence of the X^{k} $L(X)$ term in the generation equation. When the FCS generation is by the usual shift register technique, the $X^{k}L(X)$ term is added in either of two ways:

(1) Preset the shift register to all ones rather than to all zeros as in conventional generation procedures. Otherwise, shift the data $G(X)$ through the register as in conventional procedures, or,

(2) Invert the first 16 bits of $G(X)$ before shifting into the register and shift the remaining part of $G(X)$ through the register uninverted. This requires that $G(X)$ contain at least 16 bits.

Whether 1 or 2 is used, the shift register contents, after shifting through $G(X)$, is $R(X)$. These contents are inverted bit-by-bit and transmitted as the FCS sequence.

The transmitted sequence is always (in algebraic notation):
$M(X) = X^{16}\ G(X) + FCS$

12.2 FCS Checking

The received sequence will be denoted $M^*(X)$ and may differ from the transmitted sequence $M(X)$ if transmission errors are introduced. The checking process always involves dividing the received sequence by $P(X)$ and testing the remainder. Direct division, however, does not yield a unique remainder and it is expected that in most cases the received sequence will be modified for checking purposes by the addition of terms which will cause the division to yield such a unique remainder when $M^*(X) = M(X)$, i.e., when the frame is error free.

Two classes of checking equations are given below:

$$\frac{X^{\gamma}[M^*(X) + X^k L(X)]}{P(X)} = Q(X) + \frac{R(X)}{P(X)} \qquad \text{(Equation 1)}$$

In this case the unique remainder is the remainder of the division $X^{\gamma}\frac{L(X)}{P(X)}$

When $\gamma = 0$ the remainder is $L(X)$ (16 ones).
When $\gamma = 16$ the remainder is $X^{12} + X^{11} + X^{10} + X^{8} + X^{3} + X^{2} + X + 1$ (X^{15} through X^{0} respectively).

$$\frac{X^{\gamma}[M^*(X)^k + (X + 1) L(X)]}{P(X)} = Q(X) + \frac{R(X)}{P(X)} \qquad \text{(Equation 2)}$$

In this case the unique remainder is always zero regardless of the value of γ.

Shift register implementation of the above equations normally use $\gamma = 16$ (pre-multiplication). When this is the case, the added term $X^k L(X)$ in Equations 1 and 2 is added by either inverting the first 16 received bits of $M^*(X)$ before shifting them through the checking register or by presetting the register to all "1"s and shifting all of $M^*(X)$ through normally. Thus the receiver action on the leading portion of a frame is the same with either Equation 1 or 2.

The +1 of the term $(X^k + 1)L(X)$ of Equation 2 is added by inverting the FCS. This implies a 16 bit storage delay by the FCS function at the receiver since the location of the FCS is not known until the closing flag is received.

Appendixes

(These Appendixes are not a part of American National Standard for Advanced Data Communication Control Procedures (ADCCP), ANSI X3.66-1979, but are included for information purposes only.)

APPENDIX A - GLOSSARY

Abort: A function invoked by a sending station causing the recipient to discard (and ignore) all bit sequences transmitted by the sender since the preceding flag sequence.

Accept: The condition assumed by a station upon accepting a correctly received frame for processing. A station "accepts" a command/response when the command/response encoded in the control field of the received frame is actioned.

Acknowledge: A station "acknowledges" a received frame when it transmits an appropriate frame(s) indicating the received frame has been actioned.

Action: A station "actions" a received command/response when it performs (or executes) the functions encoded in the control field of the frame.

ADCCP: Advanced Data Communication Control Procedures.

Address field (A): The sequence of eight (or any multiple of eight if extended) bits immediately following the opening flag of a frame identifying the secondary/combined station sending a response frame (or designated to receive a command frame).

Address field extension: Enlarging the address field to include more addressing information.

Combined station: That station responsible for performing balanced link level operations. A combined station (1) generates commands and interprets responses and (2) interprets received commands and generates responses.

Command: The content of the control field of a command frame sent by the primary/combined station instructing the addressed secondary/combined station to perform some specific link level function.

Command frame: All frames that are transmitted by the primary

station (or by a combined station that has the remote/receiving combined station address) are referred to as command frames.

<u>Configurable station</u>: A station is configurable if it has as the result of mode-setting action, the capability to be, at different times, more than one type of logical station; i.e., primary station, secondary station, or combined station.

<u>Control field</u> (<u>C</u>): The sequence of eight (or sixteen if extended control field) bits immediately following the address field of a frame. The content of the control field is interpreted by the receiving:

(1) Secondary station, designated by the address field, as a command instructing the performance of some specific function.

(2) Primary station, as a response from the secondary station, designated by the address field, to one or more commands.

(3) Combined station, (a) as a command instructing the performance of some specific function, if the address field designates the receiving combined station, (b) as a response to one or more transmitted commands if the address field designates the remote combined station.

<u>Control field extension</u>: An enlargement of the control field to include additional control information.

<u>Data link</u>: An assembly of two or more terminal installations and the interconnecting line operating according to a particular method that permits information to be exchanged; in this context the term "terminal installation" does not include the data source and the data sink.

<u>Discard</u>: A station may "discard" all or part of a received frame:

(1) A "discarded" frame is a received frame whose control and information fields are not examined or used; i.e., the station takes no action on any part of the frame.

(2) A "received" frame may have its information field (I/UI) "discarded", i.e., the control field of the frame is used but the information field is ignored.

<u>Exception condition</u>: The condition assumed by a station upon receipt of a control field which it cannot execute due to either a transmission error or an internal processing malfunction.

<u>Flag sequence</u>(<u>F</u>): The unique sequence of eight bits(01111110) employed to delimit the opening and closing of a frame.

Frame: The sequence of contiguous bits, bracketed by and including opening and closing flag sequences. A valid frame contains at least 32 bits between flags and contains an address field, a control field and a frame check sequence. A frame may or may not include an information field.

Frame check sequence (FCS): The field, immediately preceding the closing flag sequence of a frame, containing the bit sequence that provides for the detection of transmission errors by the receiving station.

High level: The conceptual level of control or processing logic existing in the hierarchical structure of a station that is above the link level and upon which the performance of link level functions are dependent, e.g., device control, buffer allocation, station management, etc.

Implement: A command/response is implemented if it is part of the receiving station's repertoire; i.e., the receiving station is capable of decoding and actioning the control field in the received command/response.

Information field: The sequence of bits ocurring between the last bit of the control field and the first bit of the frame check sequence. The information field contents are not interpreted at the link level.

Interframe time fill: The sequence of bits transmitted between frames. This standard does not provide for time fill within a frame.

Invalid received frame:

(1) An invalid frame is one that is not properly bounded by two flags (thus an aborted frame is an invalid frame) or one that is too short (e.g., shorter than 32 bits between flags).

(2) An invalid command/response is a frame which has a control field encoding which is not defined in this standard.

(3) An invalid N(R) is one which points to an I frame which has previously been transmitted _and_ acknowledged, or to an I frame which has not been transmitted _and_ is not the next sequential I frame pending transmission.

Link level: The conceptual level of control or processing logic existing in the hierarchical structure of a station that is responsible for maintaining control of the data link. The link level functions provide an interface between the station high level logic and the data link; these functions include (transmit) bit injection and (receive) bit extraction, address/control field

interpretation, command/response generation, transmission and interpretation, and frame check sequence computation and interpretation.

Primary station: That station responsible for unbalanced control of the data link. The primary station generates commands and interprets responses. Specific responsibilities assigned to the primary station include:

(1) Initialization of (data and control) information interchange

(2) Organization and control of data flow

(3) Retransmission control

(4) All recovery functions at the link level

Receive: A station "receives" a command or response frame when the incoming bit configuration is bounded by two flags, contains an address field recognized by that station, and has a correct FCS.

Respond opportunity: The link level logical control condition during which a given secondary/combined station may transmit a response frame(s).

Response: The content of the control field of a response frame advising the primary/combined station with respect to the processing by the secondary/combined station of one or more command frames.

Response frame: All frames that may be transmitted by a secondary station (or by a combined station that has the local/transmitting combined station address) are referred to as response frames.

Secondary station: That station responsible for performing unbalanced link level operations, as instructed by the primary station. A secondary station interprets received commands and generates responses.

Secondary status: The current condition of a secondary station with respect to processing the series of commands received from the primary station.

Station: The word "station" unqualified (i.e., not preceded by primary, secondary, or combined) applies to all three types of stations: primary station, secondary station, and combined station.

This appendix provides additional explanatory information to assist in the use of the standard. For ease of reference, the paragraph numbers in this appendix correspond with those in the body of the standard.

B 3.4 Frame Structure, Information Field

Although the maximum length of the information field is theoretically unlimited, it will be constrained by one or more of the following factors:

(1) Error detection capability of the FCS

(2) Channel error characteristics and data rates

(3) Station buffer sizes and strategies

(4) Logical properties of the data

B 3.1 Flag Sequence, and B 3.8 Time Fill

Although this standard permits the closing flag of one frame to be the opening flag of the next frame, it must be recognized that in certain implementations this may result in crisis time problems. Under those conditions, it may be necessary to transmit interframe time fill. The amount of time fill must be predetermined by prior mutual agreement.

B 3.9 Idle Link State

Detection of an idle link condition may require the use of a timer or an alternate clock to determine receipt of a continuous one condition for 15 bit times if the link configuration does not provide clock signals in an idle condition.

B 7.4.2.1 Unnumbered Information, UI, Command

A secondary station must respond upon receipt of a UI command frame with the P bit set to "1"; the response shall be any appropriate frame(s), one of which will have the F bit set to "1". A UI command with the P bit set to "0" solicits no response.

FORMAT	COMMAND/RESPONSE		CONTROL FIELD ENCODING: COMMAND 1 2 3 4 5 6 7 8	CONTROL FIELD ENCODING: RESPONSE 1 2 3 4 5 6 7 8	INFORMATION FIELD
Information	Information	I	0 N(S) P N(R)	0 N(S) F N(R)	O
Supervisory	Receive Ready	RR	1 0 0 0 P N(R)	1 0 0 0 F N(R)	N
	Receive Not Ready	RNR	1 0 1 0 P N(R)	1 0 1 0 F N(R)	N
	Reject	REJ	1 0 0 1 P N(R)	1 0 0 1 F N(R)	N
	Selective Reject	SREJ	1 0 1 1 P N(R)	1 0 1 1 F N(R)	N

NOTE: Information Field: O - Optional
N - Not Allowed
R - Required

Table B1 Command/Response Summary

FUNCTION	COMMAND/RESPONSE	CONTROL FIELD ENCODING: COMMAND	1 2 3 4 5 6 7 8	CONTROL FIELD ENCODING: RESPONSE	1 2 3 4 5 6 7 8	INFORMATION FIELD
Mode Set Commands	Set Normal Response Mode	SNRM	1 1 0 0 P 0 0 1			N
	Set Asynchronous Response Mode	SARM	1 1 1 1 P 0 0 0			N
	Set Asynchronous Balanced Mode	SABM	1 1 1 1 P 1 0 0			N
	Set Asynchronous Response Mode Extended	SARME	1 1 1 1 P 0 1 0			N
	Set Normal Response Mode Extended	SNRME	1 1 1 1 P 0 1 1			N
	Set Asynchronous Balanced Mode Extended	SABME	1 1 1 1 P 1 1 0			N
Mode Set/ Request	Disconnect/ Request Disconnect	DISC	1 1 0 0 P 0 1 0	RD	1 1 0 0 F 0 1 0	N
	Set Initialization Mode/ Request Initialization Mode	SIM	1 1 1 0 P 0 0 0	RIM	1 1 1 0 F 0 0 0	N

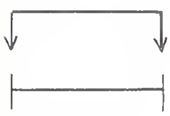
Table B1 (continued)

FUNCTION	COMMAND/RESPONSE	CONTROL FIELD ENCODING: COMMAND	COMMAND 1 2 3 4 5 6 7 8	CONTROL FIELD ENCODING: RESPONSE	RESPONSE 1 2 3 4 5 6 7 8	INFORMATION FIELD
Responses to Mode Set Commands	Unnumbered Acknowledgement			UA	1 1 0 0 F 1 1 0	N
	Disconnected Mode			DM	1 1 1 1 F 0 0 0	N
Information Transfer	Unnumbered Information	UI	1 1 0 0 P 0 0 0	UI	1 1 0 0 F 0 0 0	O
	Unnumbered Poll	UP	1 1 0 0 P 1 0 0			N
	Exchange Identification	XID	1 1 1 1 P 1 0 1	XID	1 1 1 1 F 1 0 1	O
Recovery	Frame Reject			FRMR	1 1 1 0 F 0 0 1	R
	Reset	RSET	1 1 1 1 P 0 0 1			N
Non Reserved	NRØ		1 1 0 1 P 0 0 0		1 1 0 1 F 0 0 0	O
	NR1		1 1 0 1 P 0 1 0		1 1 0 1 F 0 1 0	O
	NR2		1 1 0 1 P 0 0 1		1 1 0 1 F 0 0 1	O
	NR3		1 1 0 1 P 0 1 1		1 1 0 1 F 0 1 1	O

Table B1 (concluded)

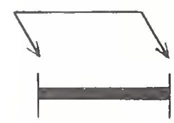
The examples in Appendix C are offered for illustrative purposes only and should not be interpreted as establishing any protocol; the exchange of the various command and response frames is limited only by the rules specified in the standard.

The notation used in the Appendix C diagrams is illustrated below:



Flag (i.e., frame boundary)

Frame containing information



Frame without information

UNBALANCED MODE OPERATION

Information Format Frame

Send Sequence Number

Information Frame: I N(S),N(R) P/F ← Poll or Final Bit set to "1"

Receive Sequence Number (next expected frame).

Example: Pri xmits: I2,6P. This denotes a primary information format frame with sequence number 2; the next expected frame from the secondary station is sequence number 6 (frames numbered 5 and below are therefore acknowledged); and the poll bit is set to "1" (i.e., the secondary station is to initiate transmission with information format frames if available).

Supervisory Command/Response

Supervisory Frame: XXX N(R),P/F ← Poll or Final Bit set to "1"

Receive Sequence Number

Example: Pri xmits: RR2,P. This denotes a receive ready (RR) command, N(R)=2 (i.e., the next expected frame from the secondary station is sequence number 2); the poll bit is set to "1".

Unnumbered Frame: YYYY,P/F

Unnumbered Command/Response

Poll or Final Bit set to "1"

Example: Pri xmits: SNRM,P. This denotes a set normal response mode (SNRM) command with the poll bit set to "1".

BALANCED MODE OPERATION

Balanced mode operation notation is identical to that of the unbalanced mode except that a station address must be indicated in order to designate the frame as a command or a response.

Information Frame: A,I N(S),N(R) P/F

Address: remote station address indicates frame is a command; local station address indicates frame is a response.

Example: Combined xmits: A,I2,6P. This denotes a command information format frame with sequence number 2; the next expected frame is sequence number 6; the poll bit is set to "1".

Supervisory Frame: A,XXX N(R),P/F

Example: Combined xmits: B,RR2,F. This denotes a response receive ready (RR) with N(R) = 2; the final bit is set to "1".

Unnumbered Frame: A,YYYY,P/F

Example: Combined xmits: A,SABM,P. This denotes a set asynchronous balanced mode (SABM) command with the poll bit set to "1".

NOTE: (1) Retransmitted information format frames are shown with a double line: i.e.,

(2) In this Appendix only, zero is denoted by: "Ø"

INDEX TO EXAMPLES ON PAGES 84-103

		APPLICABLE CLASSES	TYPE OF RECOVERY ILLUSTRATED
3.2	Command Frame Errors		
	3.2.1 I Frame	UN	REJ
	3.2.2 I Frame	UN	SREJ
3.3	Response Frame Errors		
	3.3.1 I Frame	UN	REJ
	3.3.2 I Frame	UN	SREJ
4.	ARM - TWS EXAMPLES		
4.1	No Errors		
	4.1.1 Intermittent I Frames From Primary and Secondary	UA	-
	4.1.2 Continuous I Frames From Primary and Secondary	UA	-
4.2	Command Frame Errors		
	4.2.1 Start-Up	UA	TO
	4.2.2 I Frame	UA	REJ
	4.2.3 I Frame	UA	SREJ
	4.2.4 I Frame	UA	P/F
4.3	Response Frame Errors		
	4.3.1 I Frame	UA	REJ
	4.3.2 I Frame	UA	SREJ
	4.3.3 I Frame	UA	P/F
5.	MODE CHANGING EXAMPLES		
5.1	NRM to ARM - TWA Examples		
	5.1.1 Orderly Change, Primary and Secondary I Frames	UN to UA	-
	5.1.2 Orderly Change, Primary Only I Frames	UN to UA	-
	5.1.3 Orderly Change, Secondary Only I Frames	UN to UA	-
5.2	NRM to ARM - TWS Examples		
	5.2.1 Immediate Change, Primary and Secondary I Frames	UA to UN	-
	5.2.2 Orderly Change, Primary Only I Frames	UA to UN	-
	5.2.3 Orderly Change, Secondary Only I Frames	UA to UN	-
5.3	ARM to NRM - TWA Examples		
	5.3.1 Orderly Change, Primary and Secondary I Frames	UA to UN	-
	5.3.2 Orderly Change, Primary Only I Frames	UA to UN	-
	5.3.3 Orderly Change, Secondary Only I Frames	UA to UN	-

			APPLICABLE CLASSES	TYPE OF RECOVERY ILLUSTRATED
5.4	ARM to NRM - TWS Examples			
	5.4.1	Immediate Change, Primary and Secondary I Frames	UA to UN	-
	5.4.2	Orderly Change, Primary Only I Frames	UA to UN	-
	5.4.3	Immediate Change, Secondary Only I Frames	UA to UN	-
5.5	NDM/ADM Examples			
	5.5.1	NDM/ADM to ARM - TWA	UA	-
	5.5.2	NDM/ADM to NRM - TWA	UN	-
	5.5.3	ADM to ARM - TWA, Primary Actions Secondary Request for Mode-Setting Command	UA	-
	5.5.4	NDM/ADM - TWA, Primary Refuses Secondary Request for Mode-Setting Command	UA and UN	-
6.	CLOSING PROCEDURE EXAMPLES			
	6.1	NRM-TWA	UN	-
	6.2	NRM-TWS	UN	-
	6.3	ARM-TWA	UA	-
	6.4	ARM-TWS	UA	-
7.	EXCEPTION RECOVERY - TWS EXAMPLES			
7.1	REJ and P/F Bit Exception Recovery			
	7.1.1	NRM, Secondary Receives REJ	UN	REJ
	7.1.2	NRM, Secondary Misses REJ	UN	P/F
	7.1.3	ARM, Secondary Receives REJ	UA	REJ
	7.1.4	ARM, Secondary Misses REJ	UA	P/F
7.2	SREJ/REJ Exception Recovery			
	7.2.1	NRM TWS, Primary Receives SREJ	UN	SREJ
	7.2.2	NRM TWS, Primary Misses SREJ	UN	SREJ
	7.2.3	ARM TWS, Primary Receives SREJ	UA	SREJ
	7.2.4	ARM TWS, Primary Misses SREJ	UA	SREJ
	7.2.5	ARM TWS, SREJ Missed Twice	UA	SREJ

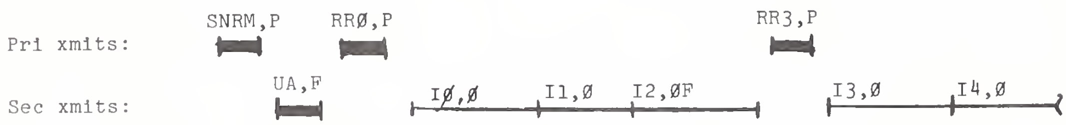
		APPLICABLE CLASSES	TYPE OF RECOVERY ILLUSTRATED
8.	BALANCED CONTROL OPERATION EXAMPLES		
8.1	Continuous I Frames, No Errors	BA	-
8.2	Intermittent I Frames, With Errors	BA	P/F
8.3	Simultaneous Mode-Setting Actions		
8.3.1	Contention SABM-SABM	BA	-
8.3.2	Contention SABM-SABM (Errors)	BA	TO
8.3.3	Contention DISC-DISC	BA	-
8.3.4	Contention DISC-DISC (Errors)	BA	TO
8.3.5	Contention DISC-SABM	BA	-
8.3.6	Contention DISC-SABM (Errors)	BA	TO
8.5.7	Contention SABME-SABM	BA	-
8.3.8	Contention SABME-SABM (Errors)	BA	TO
9.	ARM TWS POINT-TO-POINT		
9.1	Continuous Primary and Secondary I Frames	UA	-
9.2	Continuous Primary and Intermittent Secondary I Frames	UA	-
9.3	Intermittent Primary and Continuous Secondary I Frames	UA	-
10.	SYMMETRICAL TWS POINT-TO-POINT		
10.1	Start-Up/Continuous Primary and Secondary I Frames	UA and UN	-
10.2	Start-Up/Continuous Primary Only I Frames (via RNR)	UN	-
10.3	Start-Up/Continuous Primary Only I Frames (Optional Function)	UN	-

APPENDIX

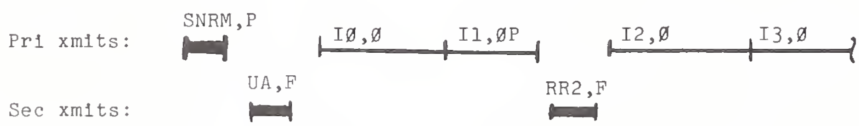
1. Examples of normal response mode (NRM) two-way alternate (TWA) transmission

1.1 NRM TWA without transmission errors

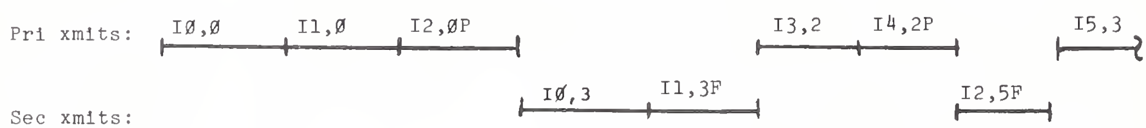
1.1.1 NRM start-up procedure and secondary-only information transfer



1.1.2 NRM start-up procedure and primary-only information transfer

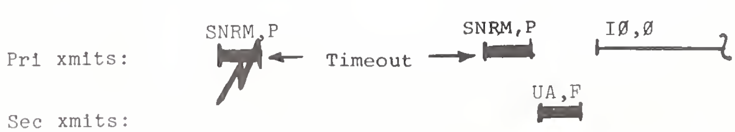


1.1.3 NRM information transfer by primary and secondary

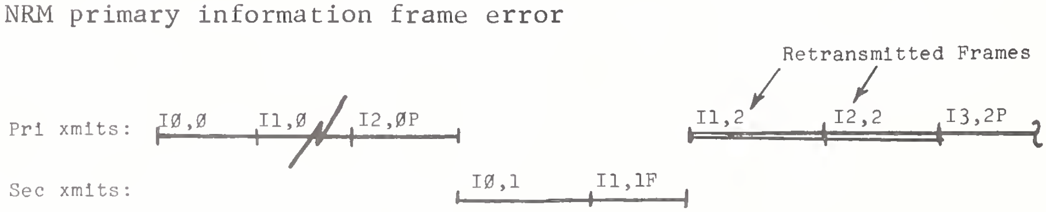


1.2 NRM TWA with transmission errors in command frames

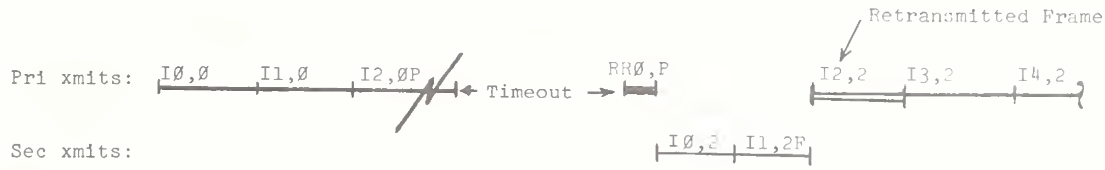
1.2.1 NRM start-up command error



1.2.2 NRM primary information frame error

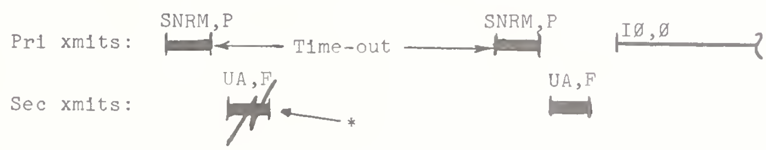


1.2.3 NRM primary poll frame error



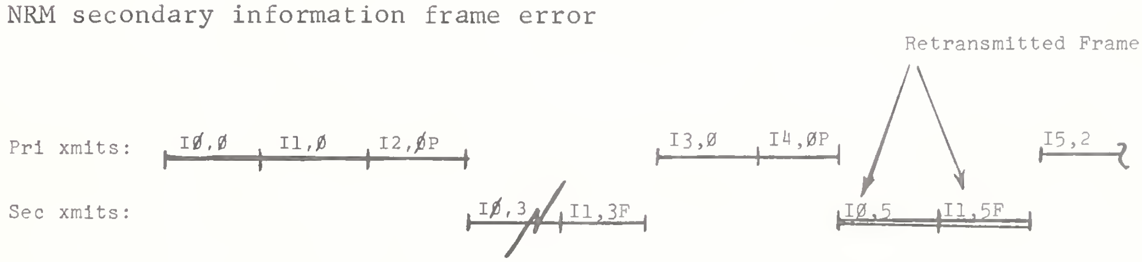
1.3 NRM TWA with transmission errors in response frames

1.3.1 NRM start-up response error

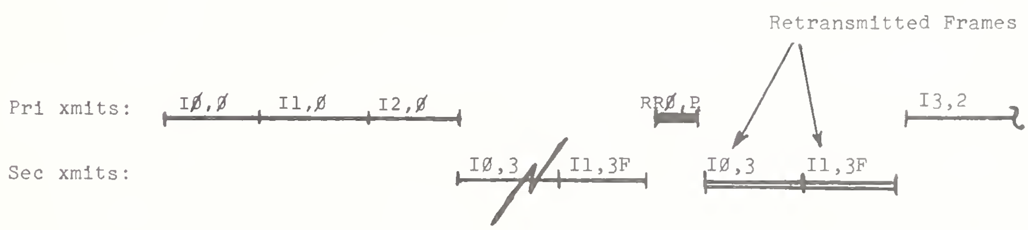


*Idle link state detection may be used in place of timeout to initiate primary transmission.

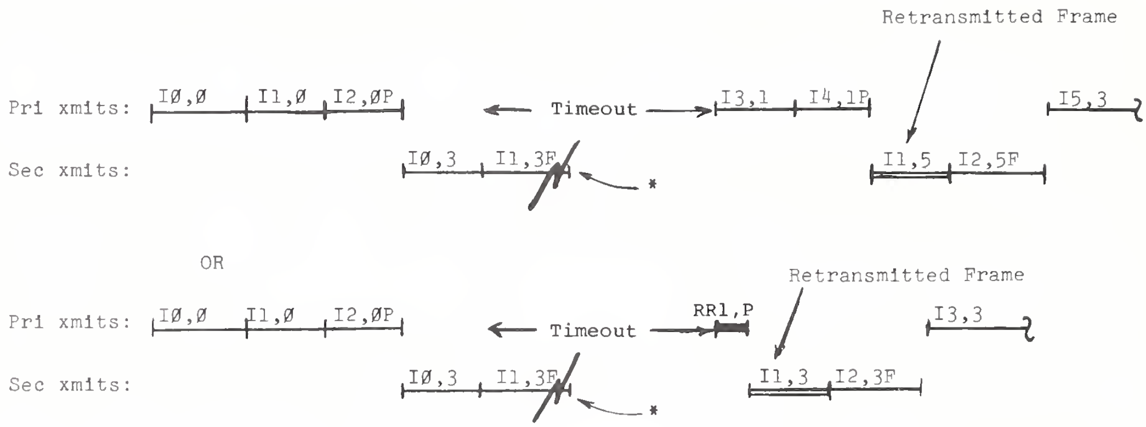
1.3.2 NRM secondary information frame error



OR

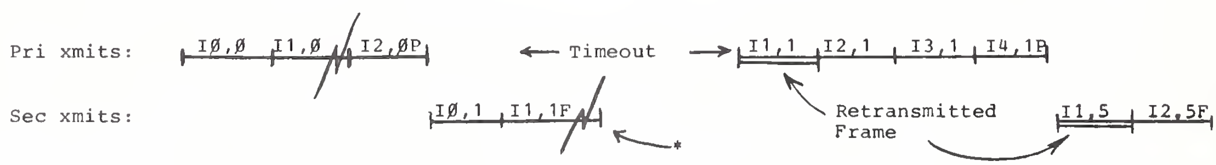


1.3.3 NRM secondary "final" frame error



1.4 NRM TWA command and response frame errors

1.4.1 NRM TWA primary I and secondary "final" I frame errors



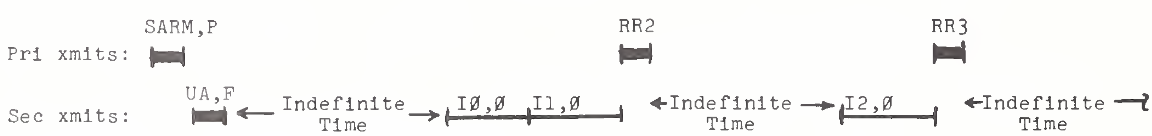
*Idle link state detection may be used in place of timeout to initiate primary transmission.

2. Examples of asynchronous respond mode (ARM) two-way alternate (TWA) transmission

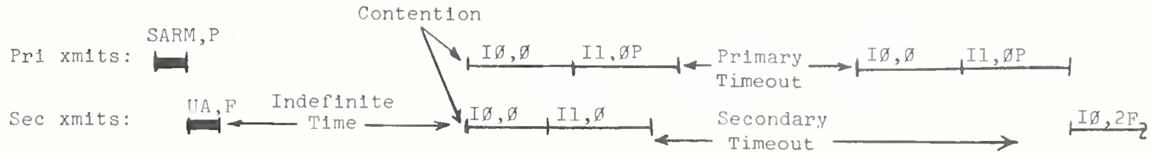
NOTE: All turnarounds in ARM TWA are by means of idle link state detection

2.1 ARM TWA without transmission error

2.1.1 ARM start-up procedure and secondary-only information transfer

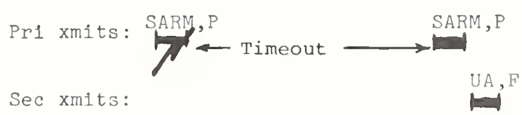


2.1.2 ARM primary and secondary information transfer with contention situation

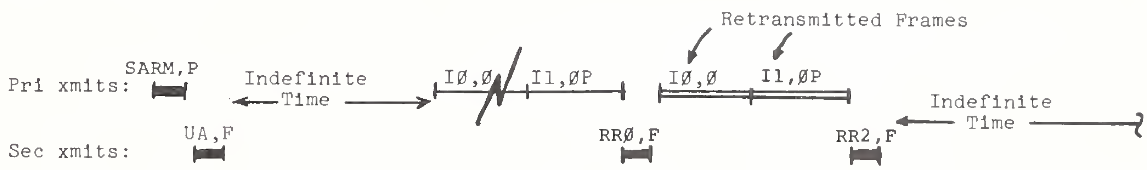


2.2 ARM TWA with transmission errors in command frames

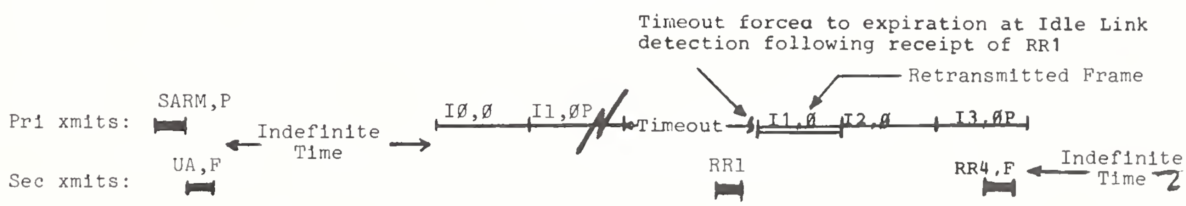
2.2.1 ARM start-up command error



2.2.2 ARM primary information frame error

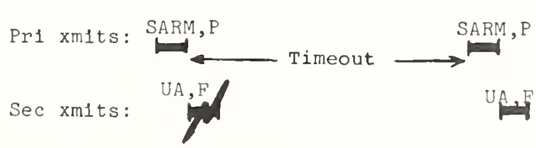


2.2.3 ARM primary "poll" information frame error

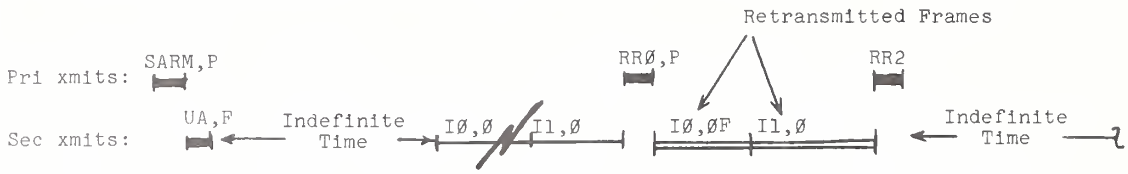


2.3 ARM TWA with transmission errors in response frames

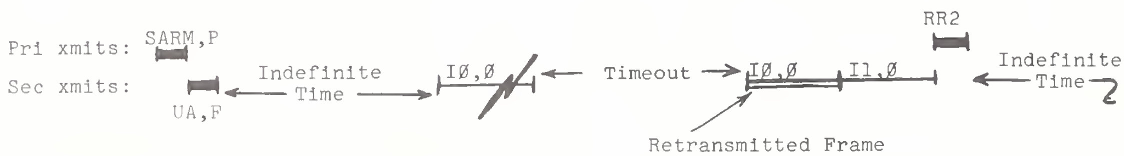
2.3.1 ARM start-up



2.3.2 ARM secondary information frame error



2.3.3 ARM secondary information frame error -- no reply received

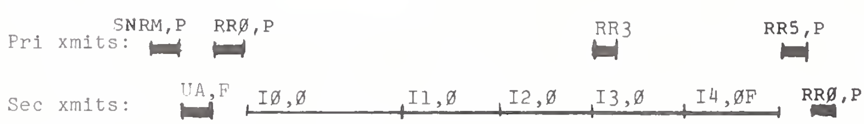


3. Examples of normal response mode (NRM) two-way simultaneous (TWS) transmission

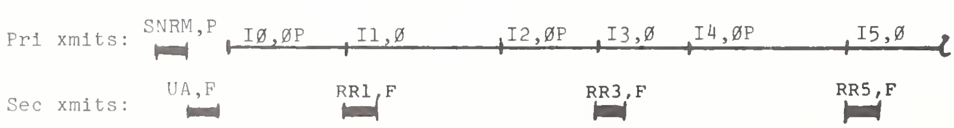
3.1 NRM TWS without transmission errors

3.1.1 NRM start-up procedure and secondary-only information transfer

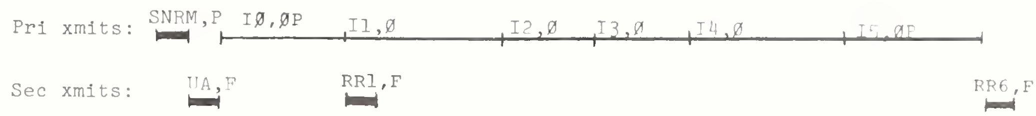
or, where primary acknowledgements are returned for several response frames



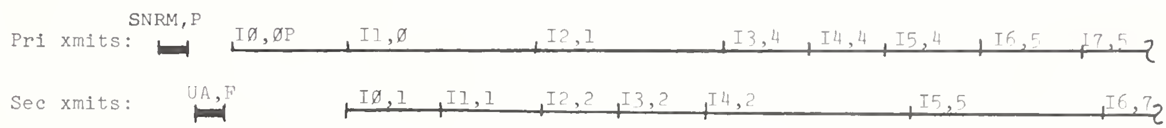
3.1.2 NRM start-up procedure and primary-only information transfer



or, where primary sets poll bit to "1" to solicit acknowledgement for several frames

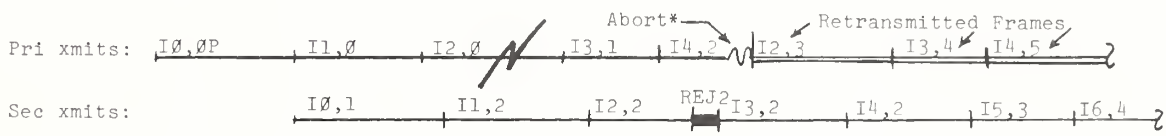


3.1.3 NRM start-up procedure and primary/secondary information transfer



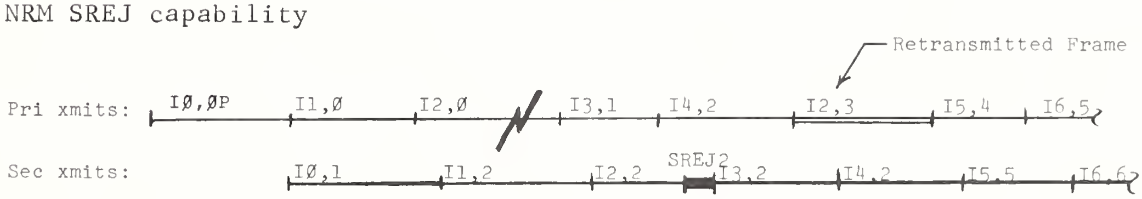
3.2 NRM TWS with transmission errors in command frames

3.2.1 NRM REJ capability



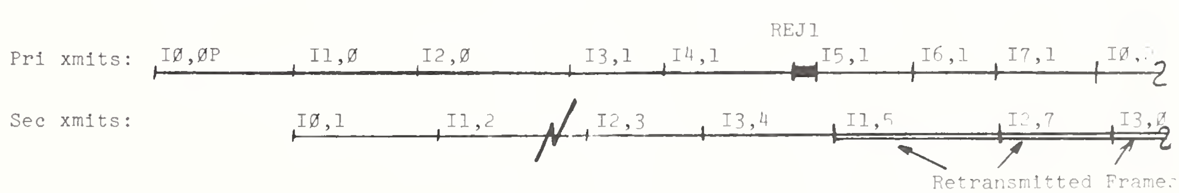
* Optional: Frame may be completed or aborted

3.2.2 NRM SREJ capability

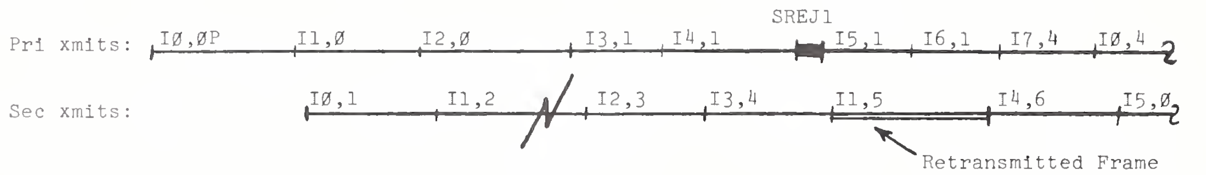


3.3 NRM TWS with transmission errors in response frames

3.3.1 NRM REJ capability



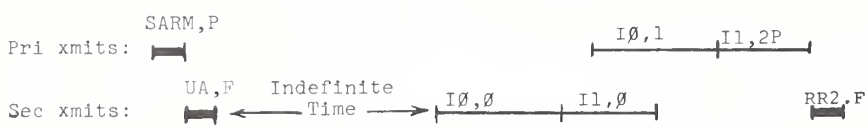
3.3.2 NRM SREJ capability



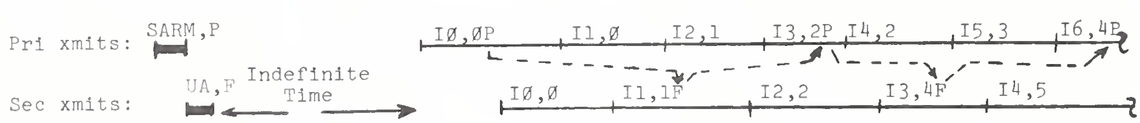
4. Examples of asynchronous response mode (ARM) two-way simultaneous (TWS) transmission

4.1 ARM TWS without transmission errors

4.1.1 ARM start-up procedure and intermittent secondary or primary information transfer

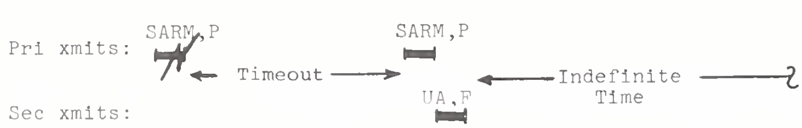


4.1.2 ARM start-up procedure and continuous primary secondary information transfer

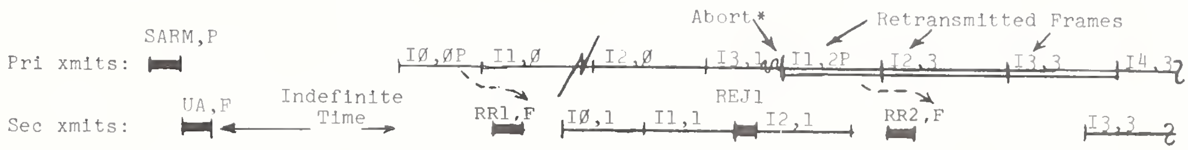


4.2 ARM TWS with transmission errors in command frames

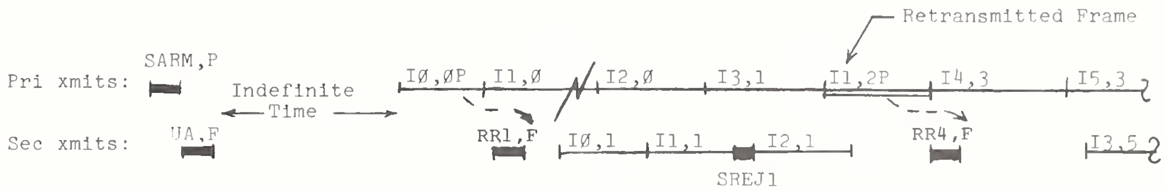
4.2.1 ARM start-up command error



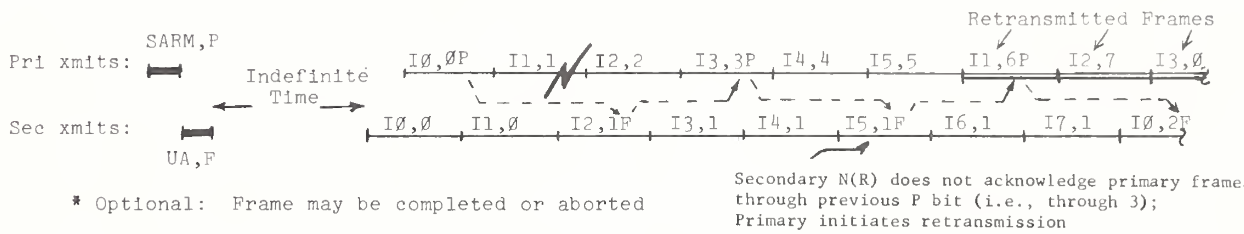
4.2.2 ARM REJ capability



4.2.3 ARM SREJ capability



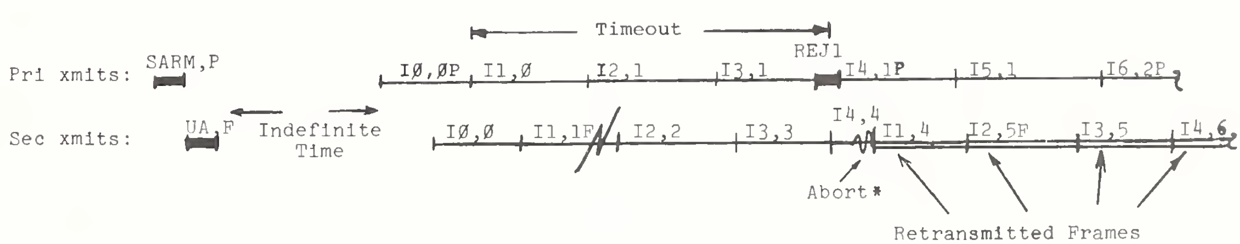
4.2.4 ARM P/F bit recovery with transmission error in command frame



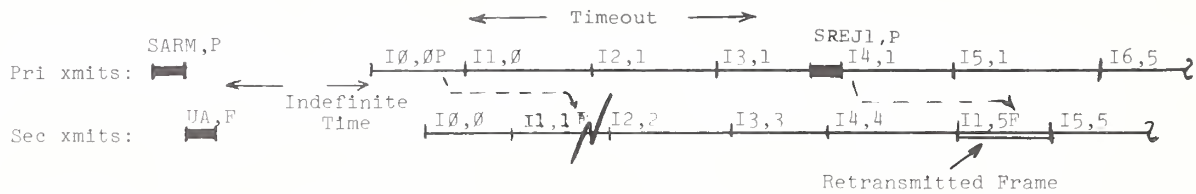
* Optional: Frame may be completed or aborted

4.3 ARM TWS with transmission errors in response frames

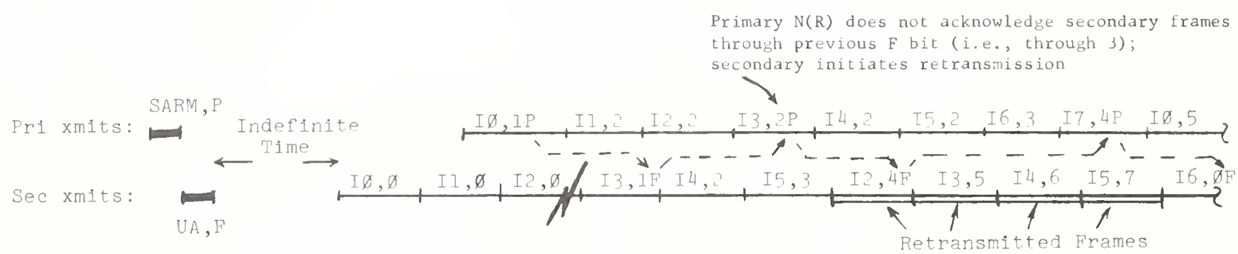
4.3.1 ARM TWS capability



4.3.2 ARM SREJ capability



4.3.3 ARM P/F bit recovery with transmission error in response frame

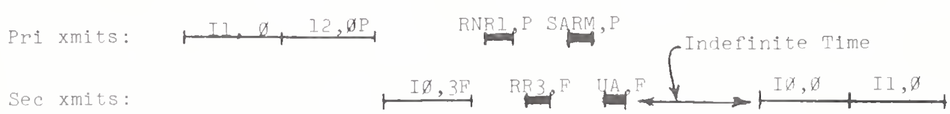


*Optional: Frame may be completed or aborted.

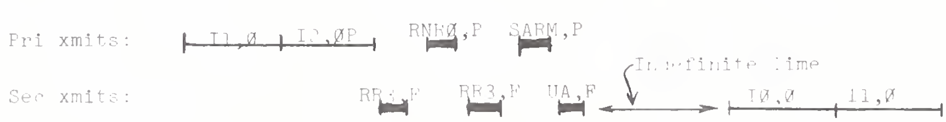
5. Examples of changing control mode

5.1 NRM to ARM two-way alternate (TWA)

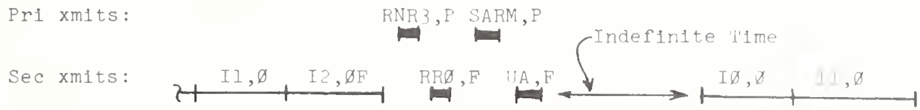
5.1.1 TWA NRM to ARM mode change



5.1.2 NRM to ARM mode change TWA

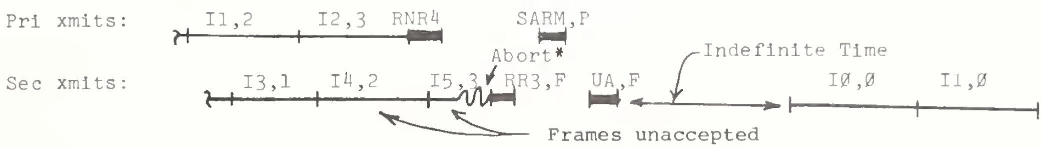


5.1.3 NRM to ARM mode change TWA

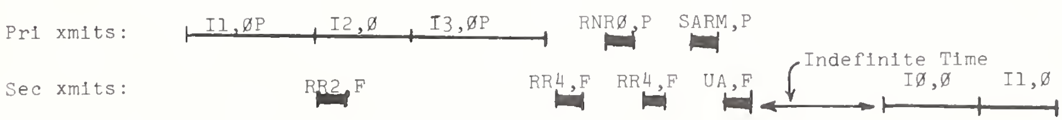


5.2 NRM to ARM two-way simultaneous (TWS)

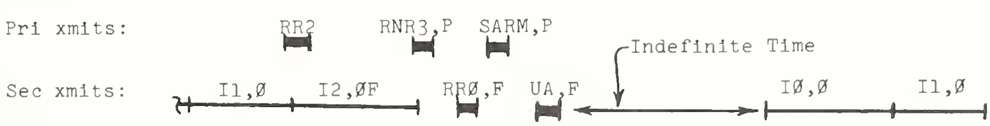
5.2.1 NRM to ARM mode change TWS (immediate change)



5.2.2 NRM to ARM mode change TWS
(orderly change while pri xmits)



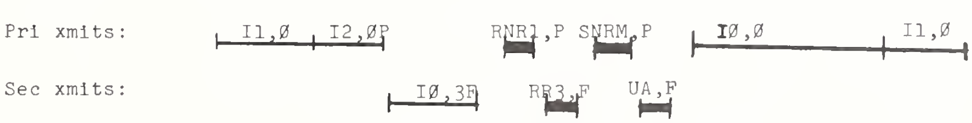
5.2.3 NRM to ARM mode change TWS
(orderly change while sec xmits)



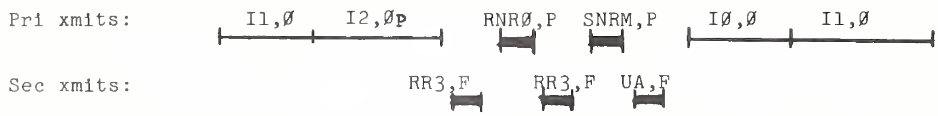
* Optional: Frame may be completed or aborted

5.3 Two-way alternate (TWA) ARM to NRM mode change

5.3.1 TWA ARM to NRM mode change



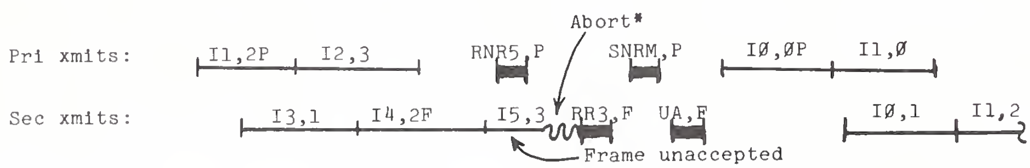
5.3.2 TWA ARM to NRM mode change



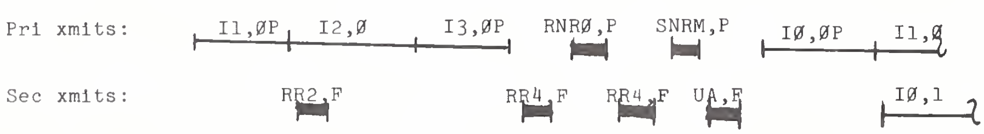
5.3.3 TWA ARM to NRM mode change

5.4 Two-way simultaneous (TWS) ARM to NRM mode change

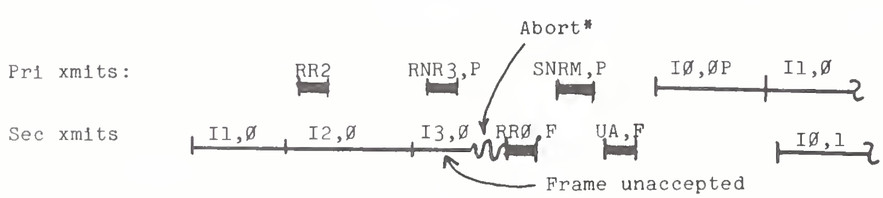
5.4.1 TWS ARM to NRM mode change (immediate change)



5.4.2 TWS ARM to NRM mode change
(orderly change while pri xmits)



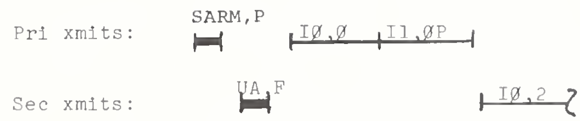
5.4.3 TWS ARM to NRM mode change
(orderly change while sec xmits)



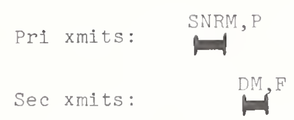
*Optional: Frame may be completed or aborted.

5.5 Examples of normal disconnect mode (NDM)

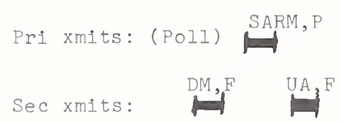
5.5.1 TWA NDM (or ADM) to ARM change



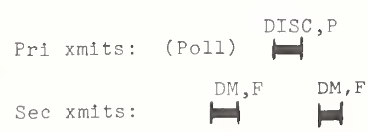
5.5.2 TWA secondary in NDM (or ADM) to NRM change
(secondary indicates it is unable to change to NRM)



5.5.3 TWA secondary in ADM
(secondary indicates it is disconnected and
primary sends set mode command)

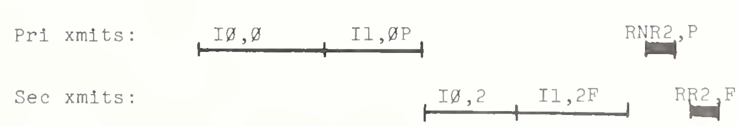


5.5.4 TWA secondary in NDM (or ADM)
(secondary indicates it is disconnected and
primary refuses to send set mode command)



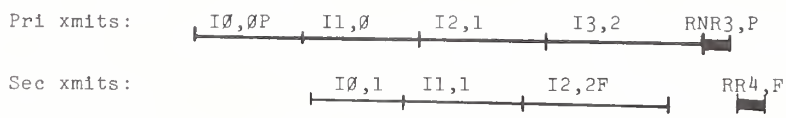
6. Examples of end of operation (general closing procedure)

6.1 NRM TWA

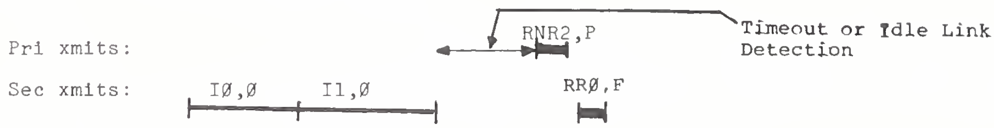


APPENDIX

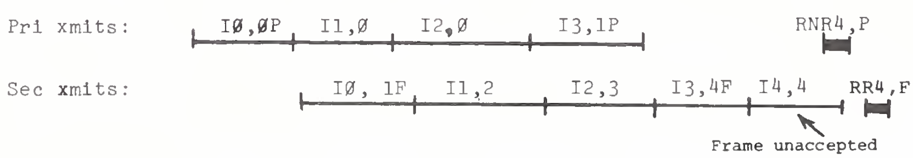
6.2 NRM TWS



6.3 ARM TWA



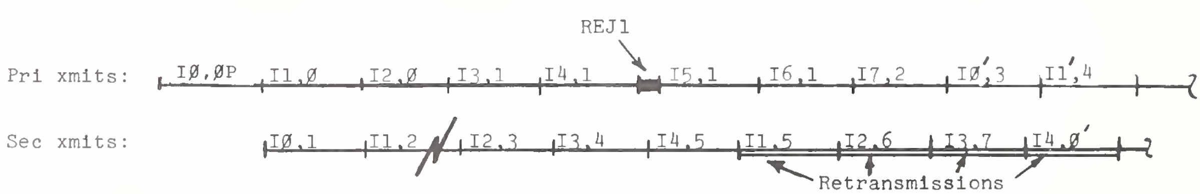
6.4 ARM TWS



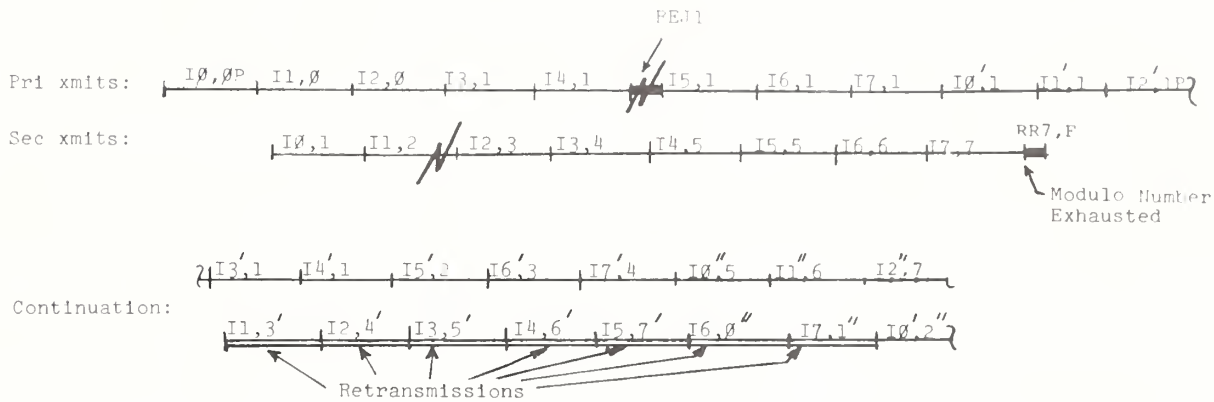
7. Examples of exception recovery procedures

7.1 REJ and P/F bit exception recovery for FDX operation

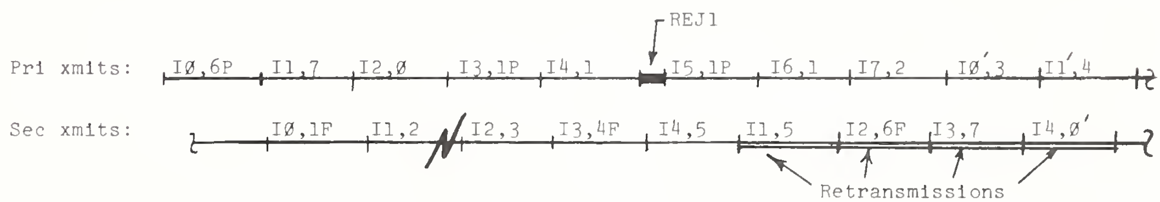
7.1.1 NRM - TWS with information frame exception



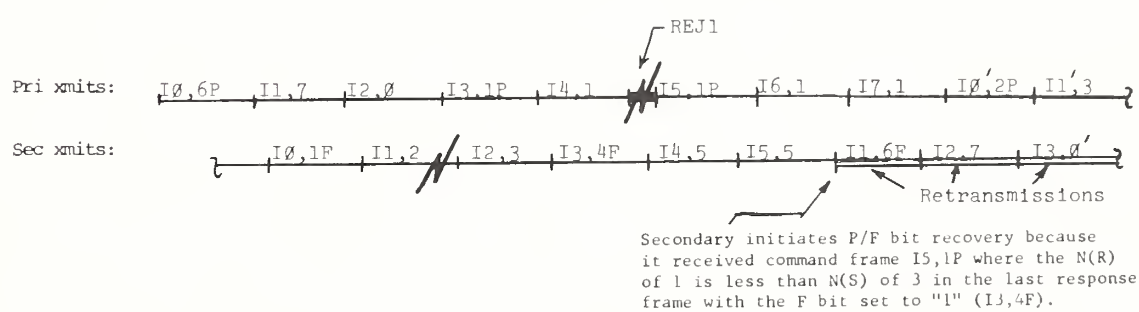
7.1.2 Example 7.1.1 above except REJ is not received correctly



7.1.3 ARM - TWS with information frame exception

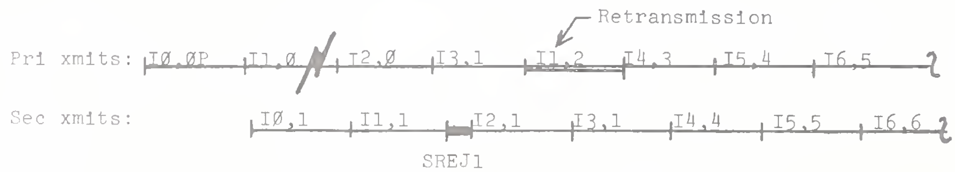


7.1.4 Example 7.1.3 above except REJ is not received correctly

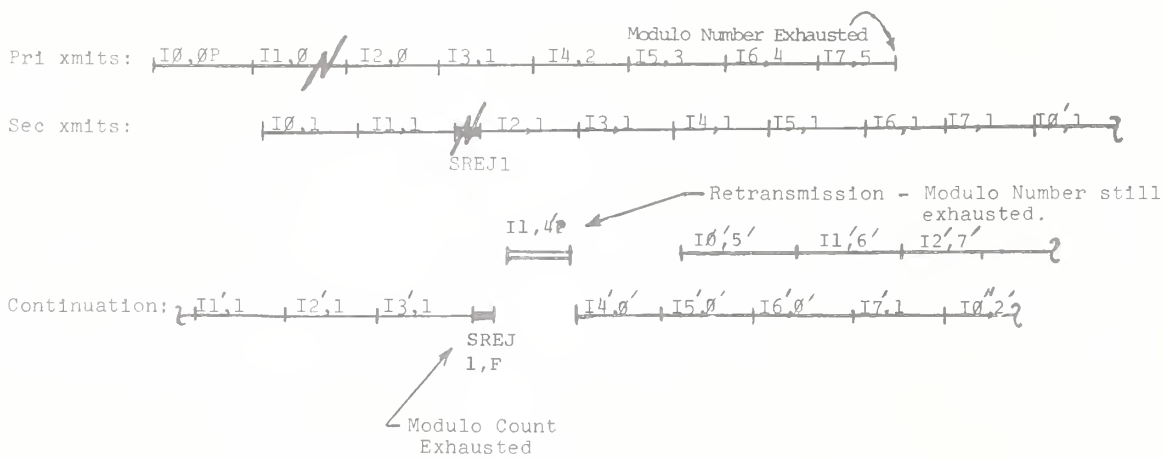


7.2 SREJ/REJ exception recovery for TWS operation

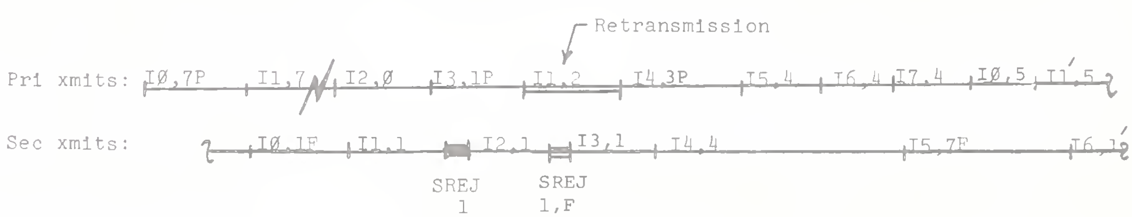
7.2.1 NRM - TWS with information frame exception



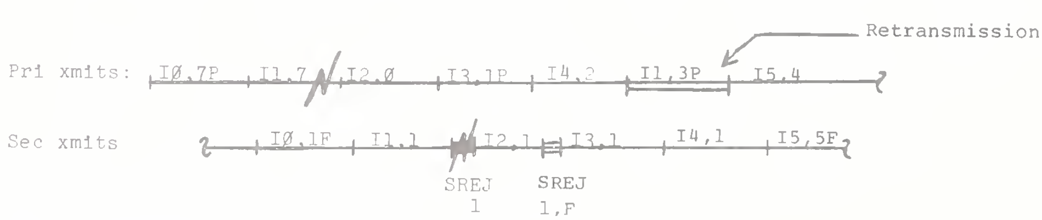
7.2.2 Example 7.2.1 above except SREJ is not received correctly



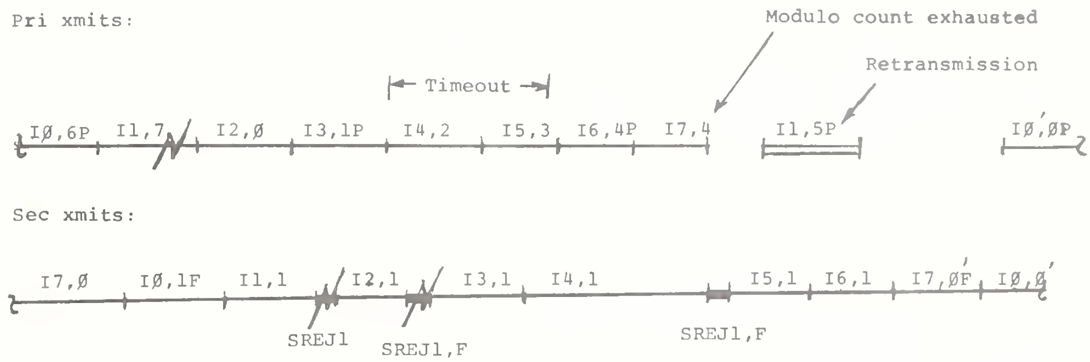
7.2.3 ARM - TWS with I frame exception condition



7.2.4 Example 7.2.3 above except SREJ is received in error

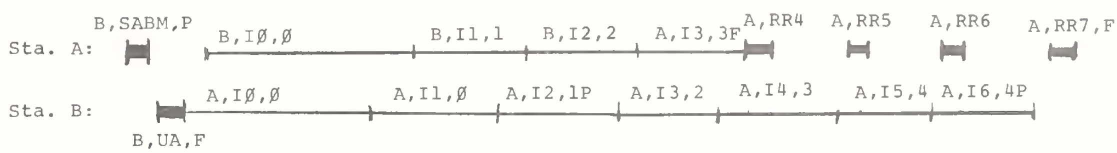


7.2.5 Example 7.2.4 above except two SREJ1 frames are received in error

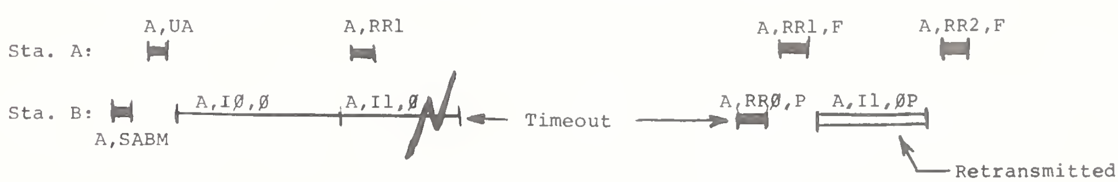


8. Examples of balanced control operation

8.1 Continuous information frames

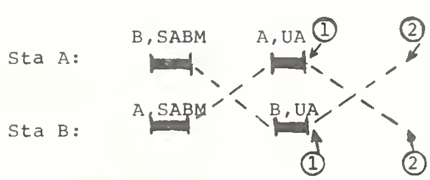


8.2 Discontinuous information frames (with error)



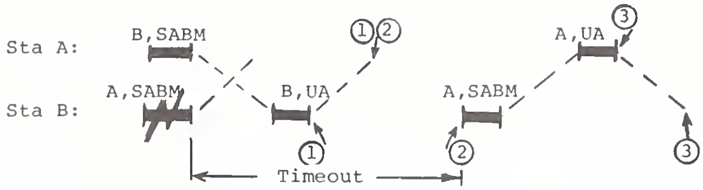
8.3 Simultaneous mode-setting actions (contention)

8.3.1 Contention between SABM and SABM



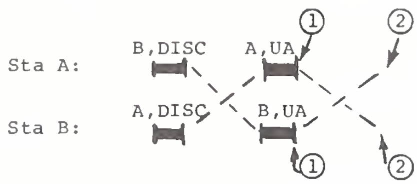
Procedure may be completed at either 1 or 2 with link available for information transfer.

8.3.2 Contention between SABM and SABM (errors)



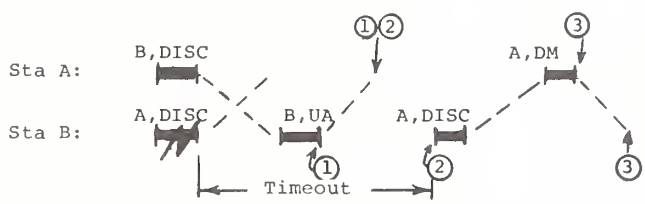
Procedure may be completed at either 1, 2 or 3 with link available for information transfer.

8.3.3 Contention between DISC and DISC



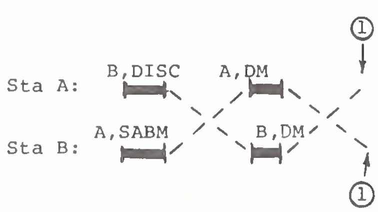
Procedure may be completed at either 1 or 2 with link in Disconnected Mode.

8.3.4 Contention between DISC and DISC (errors)



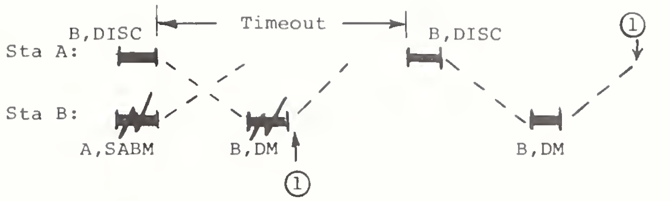
Procedure may be completed at either 1, 2 or 3 with link in Disconnected Mode.

8.3.5 Contention between DISC and SABM

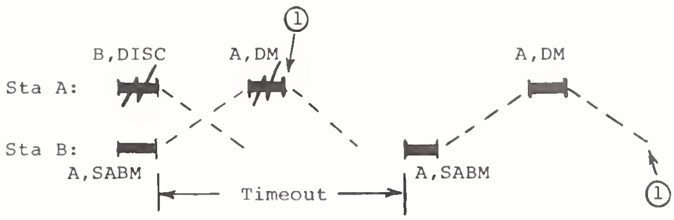


Procedure is completed at 1 with link in Disconnected Mode.

8.3.6 Contention between DISC and SABM (errors)

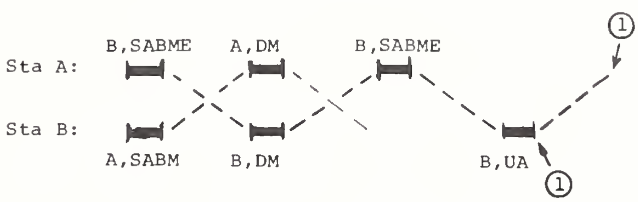


Procedure is completed at 1 with link in Disconnected Mode.



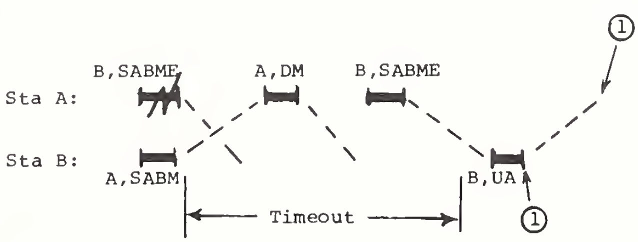
Procedure is completed at 1 with link in Disconnected Mode.

8.3.7 Contention between SABME and SABM

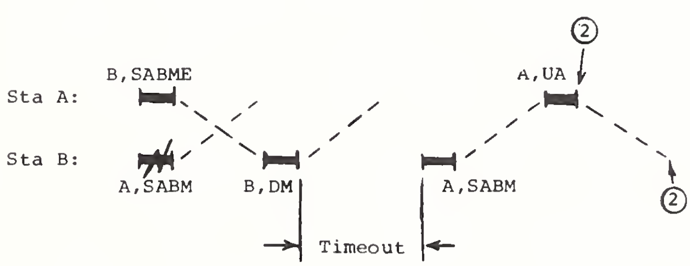


Procedure is completed at 1 with link available for information transfer in extended mode.

8.3.8 Contention between SABME and SABM (errors)



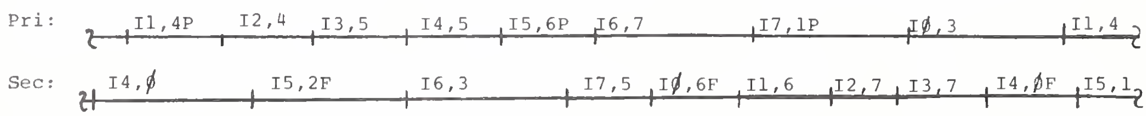
Procedure is completed at 1 with link available for information transfer in extended mode.



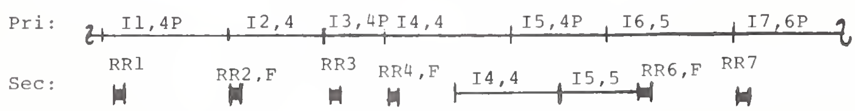
Procedure is completed at 2 with link available for information transfer in unextended mode.

9. Primary-secondary ARM two-way simultaneous point-to-point operation

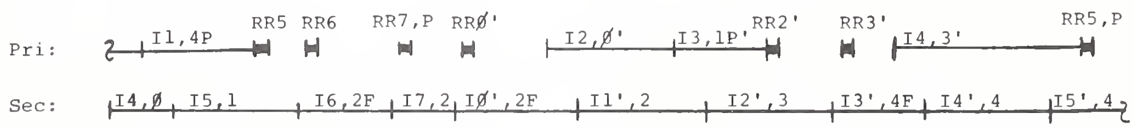
9.1 Continuous information frames from primary and secondary



9.2 Continuous primary information frames

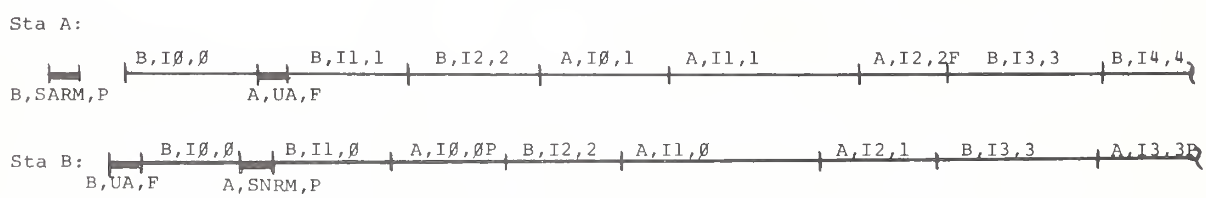


9.3 Continuous secondary information frames

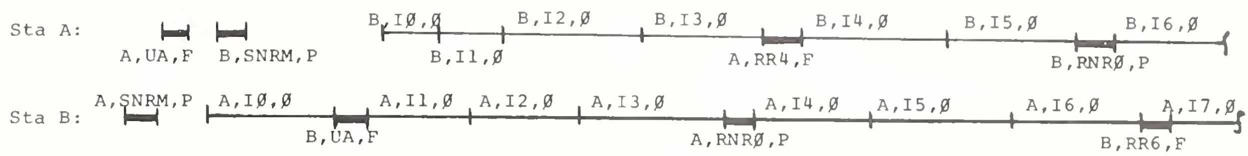


10. Symmetrical (back-to-back) primary-secondary point-to-point TWS operation (see Figure 2-3 configuration)

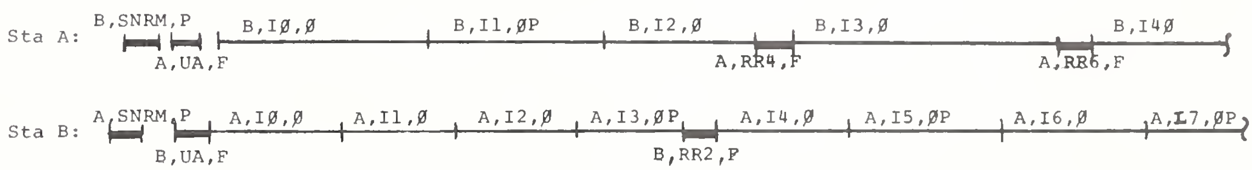
10.1 Secondary B in ARM — Secondary A in NRM operation



10.2 Use of RNR to restrict information frames from secondary operation



10.3 Secondary stations do not transmit information frames (optional function 8) operation



APPENDIX D - FRAME CHECK SEQUENCE (FCS)

D1. Description

The transmission integrity of a received message is determined by use of a frame check sequence (FCS). The FCS is generated by a transmitter, inspected by the receiver, and positioned within a frame in accordance with the following diagrams:

```
 +-------First Bit Transmitted
 |
 v
+--------------------------------------------------------------------+
| Flag | Address | Control | Information | Frame Check  | Flag |
|      |         |         |             |   Sequence   |      |
+--------------------------------------------------------------------+
       |<----------- k bits ----------->|<-- 16 bits-->|
       |             G(X)                               |
       |                                                |
       |<----------- n bits ------------------------->|
       |             M(X)                               |
```

The procedure for using the FCS assumes the following:

(1) The k bits of data which are being checked by the FCS can be represented by a polynomial G(X).

Examples:

(a) $G(x) = 10100100 = X^7 + X^5 + X^2 = X^2(X^5+X^3+1)$

(b) $G(x) = 00...010100100 = X^7+X^5+X^2 = X^2(X^5+X^3+1)$

(c) $G(x) = 101001 = X^5 + X^3 + 1$

In general, leading zeros don't change G(X) and trailing zeros add a factor of X where n is the number of trailing zeros.

(2) The address, control, and information field (if it exists in the message) are represented by the polynomial G(X).

(3) For the purpose of generating the FCS, the first bit following the opening flag is the coefficient of the highest degree term of G(x) regardless of the actual representation of the address, control, and information fields.

(4) There exists a generator polynomial P(X) of degree 16, having the form $P(X) = X^{16}+X^{12}+X^5+1$

D2. Generation and Use of FCS

The FCS is defined as a one's complement of a remainder, R(X),

obtained from the modulo two division of

$$X^{16}\ G(X)+X^{k}(X^{15}+X^{14}+X^{13}+X^{12}+X^{11}+X^{10}+X^{9}+X^{8}+X^{7}+X^{6}+X^{5}+X^{4}+X^{3}+X^{2}+X^{1}+1)$$

by the generator ploynomial P(X).

$$\frac{X^{16}\ G(X)+X^{k}(X^{15}+X^{14}\ldots+X+1)}{P(X)} = Q(X) + \frac{R(X)}{P(X)} \leftarrow \overline{FCS}$$

The multiplication of G(X) by X^{16} corresponds to shifting the message G(X), 16 places and thus providing the space of 16 bits for the FCS.

The addition of $X^{k}(X^{15}+X^{14}\ldots+X+1)$ to $X^{16}\ G(X)$ is equivalent to inverting the first 16 bits of G(X). It can also be accomplished in a shift register implementation by presetting the register to all "ones" initially. This term is present to detect erroneous additon of deletion of zero bits at the leading end of M(X) due to erroneous flag shifts.

The complementing of R(X) by the transmitter at the completion of the division insures that the transmitted sequence M(X) has a property which permits the receiver to detect addition or deletion of trailing zeros which may appear as a result of errors.

At the transmitter the FCS is added to the X^{16} G(X) and results in the total message M(X) of length K+16, where $M(X) = X^{16}\ G(X) +$ FCS.

The reeiver can employ one of several detection processes, two of which are discussed here. In the first process, the incoming M(X) (assuming no errors; i.e., M*(X) = M(X)) is multiplied by X^{16}, added to $X^{k+16}\ (X^{15} + X^{14}\ \ldots +X +1)$ and divided by P(X).

$$\frac{X^{16}\,[X^{16}\ G(X) + FCS] + X^{k+16}\ (X^{15} + X^{14}\ \ldots + X + 1)}{P(X)} =$$

$$Qr(X) + Rr(X)/P(X)$$

Since the transmission is error free, the remainder Rr(X) will be "0001110100001111" (X^{15} through X^{0}).

Rr(X) is the remainder of the division: $\dfrac{X^{16}\ L(X)}{P(X)}$

where $L(X) = X^{15} + X^{14}\ \ldots +X +1$. This can be shown by establishing that all other terms of the numberator of the receiver division are divisible by P(X). This will be done below.

Note that FCS $= \overline{R(X)} = L(X)+R(X)$. (Adding $L(X)$ to a polynomial of its same length is equivalent to a bit by bit inversion of the polynomial.)

The receiver division numerator can be rearranged to:

$$X^{16} [X^{16}\, G(X) + X^{k}L(X) + R(X)] + X^{16}\, L(X).$$

It can be seen by inspecting the transmitter generation equation that the first term is divisible by $P(X)$; thus the $X^{16}L(X)$ term is the only contributor to $Rr(X)$.

The second process differs from the first in that another term ($X^{16}L(X)$) is added to the numerator of the generation equation. This causes a remainder of zero to be generated if $M^{*}(X)$ is received error free.

D3. Implementation

A shift register FCS implementation is described in detail here. It utilizes "ones presetting" at both the sender and the receiver and the receiver does not invert the FCS. The receiver thus checks for the non-zero residual $Rr(X)$ to indicate an error free transmission. Figure D1 is an illustration of the implementation. It shows a configuration of storage elements and gates. The addition of $X^{k}(X^{15}+X^{14}...+X+1)$ to the $X^{16}\, G(X)$ can be accomplished by presetting all storage elements to a binary value "1".

The one's complement of $R(X)$ is obtained by the logical bit by bit inversion of the transmitter's $R(X)$.

Figure D1 shows the implementation of the FCS generation for transmission. The same hardware can also be used for verification of data integrity upon data reception.

Before transmitting data, the storage elements, $X_0 \ldots X_{15}$ are initialized to "one". The accumulation of the remainder $R(X)$ is begun by enabling the "A" and thereby enabling gates G2 and G3. The data to be transmitted goes out to the receiver via G2 and at the same time the remainder is being calculated with the use of feedback path via G3. Upon completion of transmitting the k bits of data, the "A" is disabled and the stored $R(X)$ is transmitted via G1 and I1 while G2 and G3 are disabled. The I1 provides the necessary inversion of $R(X)$.

At the receiver, before data reception, the storage elements, $X_0 \ldots X_{15}$ are initialized to "ones". The incoming message is then continuously divided by $P(X)$ via G3 ("A" enabled). If the message contained no errors, the storage elements will contain "0001110100001111" ($X_{15} \ldots X_0$) at the end of the $M^{*}(X)$.

Figure D2 is an example of the receiver and transmitter states during a transmission of a 19 bit G(X) and a 16 bit FCS.

The implementation of the FCS generation and the division by P(X) as described in this Appendix is used as an example only. Other implementations are possible and may be utilized. This standard only requires that the FCS be generated in accordance with the rules of 3.5 and 12.1 and that the checking process involve division by the polynomial P(X). Furthermore, the order of transmission of M(X) is the coefficient of the highest degree term first and thereafter in decreasing order of powers of X, regardless of the actual representation of fields internal to M(X).

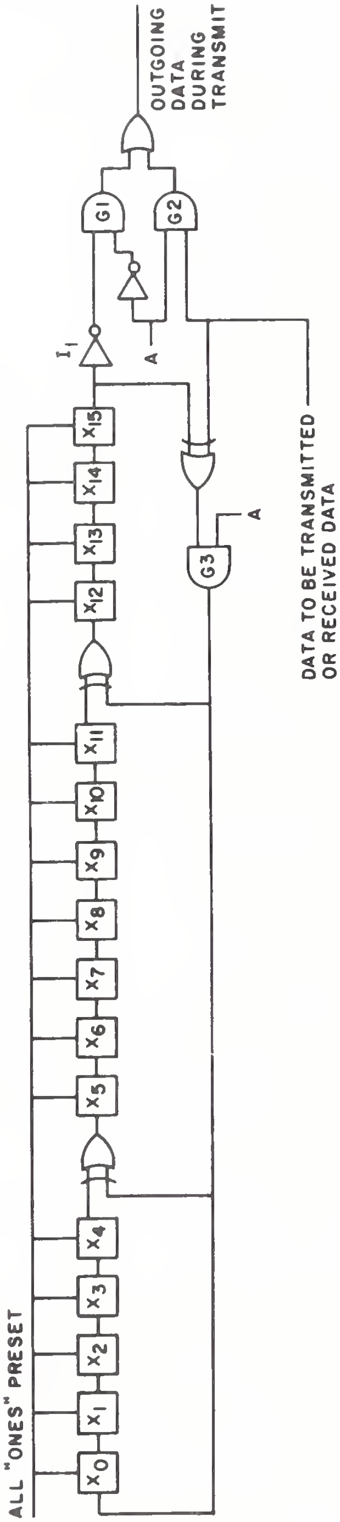


Figure D1
FCS Implementation

	INPUT TO TX	TX CRC		INPUT TO RX	RX CRC
MSB		1111111111111111			1111111111111111
	0	1111101111110111		0	1111101111110111
	1	0111110111111011		1	0111110111111011
	1	0011111011111101		1	0011111011111101
	1	0001111101111110		1	0001111101111110
	1	1000101110110111		1	1000101110110111
	0	1100000111010011		0	1100000111010011
	0	1110010011100001		0	1110010011100001
	1	0111001001110000		1	0111001001110000
G(x)	1	1011110100110000		1	1011110100110000
	0	0101111010011000		0	0101111010011000
	0	0010111101001100		0	0010111101001100
	1	1001001110101110		1	1001001110101110
	1	1100110111011111		1	1100110111011111
	0	1110001011100111		0	1110001011100111
	0	1111010101111011		0	1111010101111011
	0	1111111010110101		0	1111111010110101
	1	0111111101011010		1	0111111101011010
	1	1011101110100101		1	1011101110100101
	1	0101110111010010		1	0101110111010010
		0010111011101001		1	1010101011100001
		0001011101110100		0	1101000101111000
		0000101110111010		1	1110110010110100
		0000010111011101		1	1111001001010010
		0000001011101110	F	0	0111100100101001
		0000000101110111		1	0011110010010100
		0000000010111011	C	0	0001111001001010
		0000000001011101		0	0000111100100101
		0000000000101110	S	0	1000001110011010
		0000000000010111		1	1100010111000101
		0000000000001011		0	1110011011101010
		0000000000000101		0	0111001101110101
		0000000000000010		0	1011110110110010
		0000000000000001		1	1101101011010001
		0000000000000000		0	1110100101100000
		0000000000000000		1	1111000010111000
		X^0 … X^{15}			X^0 … X^{15}

Figure D2

FCS Example

American National Standards for Information Processing

X3.1-1976 Synchronous Signaling Rates for Data Transmission

X3.2-1970 (R1976) Print Specifications for Magnetic Ink Character Recognition

X3.3-1970 (R1976) Bank Check Specifications for Magnetic Ink Character Recognition

X3.4-1977 Code for Information Interchange

X3.5-1970 Flowchart Symbols and Their Usage in Information Processing

X3.6-1965 (R1973) Perforated Tape Code for Information Interchange

X3.9-1978 FORTRAN

X3.11-1969 Specification for General Purpose Paper Cards for Information Processing

X3.14-1973 Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)

X3.15-1976 Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

X3.16-1976 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

X3.17-1977 Character Set and Print Quality for Optical Character Recognition (OCR-A)

X3.18-1974 One-Inch Perforated Paper Tape for Information Interchange

X3.19-1974 Eleven-Sixteenths-Inch Perforated Paper Tape for Information Interchange

X3.20-1967 (R1974) Take-Up Reels for One-Inch Perforated Tape for Information Interchange

X3.21-1967 Rectangular Holes in Twelve-Row Punched Cards

X3.22-1973 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)

X3.23-1974 Programming Language COBOL

X3.24-1968 Signal Quality at Interface between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission

X3.25-1976 Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication in the American National Standard Code for Information interchange

X3.26-1970 Hollerith Punched Card Code

X3.27-1978 Magnetic Tape Labels and File Structure for Information Interchange

X3.28-1976 Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links

X3.29-1971 Specifications for Properties of Unpunched Oiled Paper Perforator Tape

X3.30-1971 Representation for Calendar Date and Ordinal Date for Information Interchange

X3.31-1973 Structure for the Identification of the Counties of the United States for Information Interchange

X3.32-1973 Graphic Representation of the Control Characters of American National Standard Code for Information Interchange

X3.34-1972 Interchange Rolls of Perforated Tape for Information Interchange

X3.36-1975 Synchronous High-Speed Data Signaling Rates between Data Terminal Equipment and Data Communication Equipment

X3.37-1977 Programming Language APT

X3.38-1972 Identification of States of the United States (Including the District of Columbia) for Information Interchange

X3.39-1973 Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

X3.40-1976 Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE)

X3.41-1974 Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange

X3.42-1975 Representation of Numeric Values in Character Strings for Information Interchange

X3.43-1977 Representations of Local Time of the Day for Information Interchange

X3.44-1974 Determination of the Performance of Data Communication Systems

X3.45-1974 Character Set for Handprinting

X3.46-1974 Unrecorded Magnetic Six-Disk Pack (General, Physical, and Magnetic Characteristics)

X3.47-1977 Structure for the Identification of Named Populated Places and Related Entities of the States of the United States for Information Interchange

X3.48-1977 Magnetic Tape Cassettes for Information Interchange (3.810-mm [0.150-in] Tape at 32 bpmm [800 bpi], PE)

X3.49-1975 Character Set for Optical Character Recognition (OCR-B)

X3.50-1976 Representations for U.S. Customary, SI, and Other Units to Be Used in Systems with Limited Character Sets

X3.51-1975 Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange

X3.52-1976 Unrecorded Single-Disk Cartridge (Front Loading, 2200 BPI), General, Physical, and Magnetic Requirements

X3.53-1976 Programming Language PL/I

X3.54-1976 Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording)

X3.55-1977 Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250 Inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

X3.56-1977 Recorded Magnetic Tape Cartridge for Information Interchange 4 Track, 0.250 Inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

X3.57-1977 Structure for Formatting Message Headings for Information Interchange Using the American National Standard Code for Information Interchange for Data Communication Systems Control

X3.58-1977 Unrecorded Eleven-Disk Pack General, Physical, and Magnetic Requirements

X3.60-1978 Programming Language Minimal BASIC

X3.61-1978 Representation of Geographic Point Locations for Information Interchange

X3.62-1979 Paper Used in Optical Character Recognition (OCR) Systems

X3.66-1979 Advanced Data Communication Control Procedures (ADCCP)

X3/TRI-77 Dictionary for Information Processing (Technical Report)

American National Standards Institute, Inc
1430 Broadway
New York, N.Y. 10018

NIST-772
(REV. 10-88)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

FIPS PUBLICATION CHANGE NOTICE

CHANGE NUMBER 2 - 71
Change Number 1 - 78

DATE OF CHANGE
1994 July 29

FIPS PUBLICATION NUMBER
71 & 78

PUBLICATION TITLE

FIPS PUB 71, Advanced Data Communication Control Procedures (ADCCP)

FIPS PUB 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP)

THIS OFFICE HAS A RECORD OF YOUR INTEREST IN RECEIVING CHANGES TO THE ABOVE FIPS PUBLICATION. THE CHANGE(S) INDICATED BELOW HAVE BEEN PROVIDED BY THE MAINTENANCE AGENCY FOR THIS PUBLICATION AND WILL BE INCLUDED IN THE NEXT PUBLISHED REVISION TO THIS FIPS PUBLICATION. QUESTIONS OR REQUESTS FOR ADDITIONAL INFORMATION SHOULD BE ADDRESSED TO THE MAINTENANCE AGENCY:

Department of Commerce
National Institute of Standards and Technology
Computer Systems Laboratory
Gaithersburg, MD 20899

CHANGE ITEM(S)

Attached is a reprint from the June 22, 1994, FEDERAL REGISTER (59 FR 32186) which announces that the Secretary of Commerce has approved the withdrawal of two Federal Information Processing Standards (FIPS): FIPS PUB 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS PUB 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP).

FIPS 71 and 78 are withdrawn because they are no longer needed by the Federal government. Commercial products supported by this technology are no longer needed.

This withdrawal of the standards is effective June 22, 1994.

Please remove each FIPS listed above and insert this change notice.

Attachment

Copies of FIPS are available from:

National Technical Information Service (NTIS)
ATTN: Sales Office, Sills Building
5285 Port Royal Road
Springfield, VA 22161

Phone - (703) 487-4650

Office Hours - 7:45am to 5:00pm

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federal register

Wednesday
June 22, 1994

National Institute of Standards and Technology

NOTICES

Information processing standards, Federal:
Advanced data communication control procedures; withdrawn, 32186

National Institute of Standards and Technology

[Docket No. 931057-4117]

RIN 0693-AA98

Approval of Withdrawal of Federal Information Processing Standard (FIPS) 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS 78, Guideline for Implementing ADCCP

AGENCY: National Institute of Standards and Technology (NIST), Commerce.

ACTION: Notice.

SUMMARY: The purpose of this notice is to announce that the Secretary of Commerce has approved the withdrawal of Federal Information Processing Standard (FIPS) 71, Advanced Data Communication Control Procedures (ADCCP) and FIPS 78, Guideline for Implementing Advanced Data Communication Control Procedures (ADCCP).

On November 16, 1993, notice was published in the Federal Register (58 FR 60425) proposing withdrawal of Federal Information Processing Standard (FIPS) 71, because the technical specifications that they adopt are obsolete and are no longer supported by industry. NIST also stated that if FIPS 71 were withdrawn, FIPS 78 would be withdrawn as well.

The written comments submitted by interested parties and other material available to the Department relevant to this standard was reviewed by NIST. On the basis of this review, NIST recommended that the Secretary approved the withdrawal of FIPS 71 and 78, and prepared a detailed justification document for the Secretary's review in support of that recommendation.

The detailed justification document which was presented to the Secretary is part of the public record and is available for inspection and copying in the Department's Central Reference and Records Inspection Facility, Room 6020, Herbert C. Hoover Building, 14th Street between Pennsylvania and Constitution Avenues, NW., Washington, DC 20230.

EFFECTIVE DATE: This withdrawal is effective on June 22, 1994.

FOR FURTHER INFORMATION CONTACT: Ms. Shirley Radack, National Institute of Standards and Technology, Gaithersburg, MD 20899, telephone (301) 975-2833.

Authority: Federal Information Processing Standards Publications (FIPS PUBS) are issued by the National Institute of Standards and Technology after approval by the Secretary of Commerce pursuant to Section 111(d) of the Federal Property and Administrative Services Act of 1949 as amended by the Computer Security Act of 1987, Public Law 100-235.

Dated: June 17, 1994.

Samuel Kramer,

Associate Director.

[FR Doc. 94-15189 Filed 6-21-94; 8:45 am]

BILLING CODE 3510-CN-M